55.06(42.74)
cH

FOR THE PEOPLE
FOR EDVCATION
FOR SCIENCE

LIBRARY
OF
THE AMERICAN MUSEUM
OF
NATURAL HISTORY

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL & POLYTECHNIC SOCIETY.

NEW SERIES—VOLUME VIII.

1882–1884.

With Twenty-three Plates and Maps.

EDITED BY JAMES W. DAVIS, F.S.A., F.G.S., F.L.S.

LEEDS:
PRINTED BY A. MEGSON & SONS.

AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK
NEW YORK

39-144255-Feb 28

TABLE OF CONTENTS.

1882.

PAGE.

"Biographical Notices of Eminent Yorkshire Geologists, I., 'John Phillips.'" By the Editor. 3

"On the White Chalk of Yorkshire." By the Rev. E. Maule Cole, M.A., F.G.S. 12

"Glacial Sections near Bridlington." By G. W. Lamplugh. Part II., "Cliff Section extending 900 yards south of the Harbour." 27

"Notes on the Occurrence of Fossil Fish Remains in the Carboniferous Limestone Series of Yorkshire." By J. W. Davis, F.G.S. 39

"On the Lead Veins in the Neighbourhood of Skipton." By J. Ray Eddy, F.G.S. 63

"On the Discovery of Flint Implements on the Hills between Todmorden and Marsden." By Robert Law and James Horsfall. 70

"Yorkshire Fossil Mollusca." By William Cash. 77

"On the Recent Extension of Mining Operations under the Permian Formations." By Thomas William Tew, Esq., J.P.... 89

"Photograph—Thornwick Bay, Flamborough." By G. W. Lamplugh. ... 103

"On some Sections Exposed during the Formation of Line of the Railway between Upton and Kirk Smeaton." By James W. Davis, F.G.S. ... 107

"Notes on the Excursion to the West Riding of Yorkshire." By Hudleston and Davis; together with Preliminary Remarks by W. H. Hudleston, F.G.S., President of the Geologists' Association, London. 113

Secretary's Report and Balance Sheet. 136-140

Minutes. 141

Summary of Geological Literature 147

List of Members. 149

Meteorology of Bradford for 1882. By J. McLandsborough, F.G.S., and A. E. Preston, F.G.S.

1883.

"Address on the Connection between Geology and Archæology." By the Rev. W. C. Lukis, M.A., F.S.A. 157

"Notes on the Carboniferous Polyzoa of West Yorkshire and Derbyshire.—*(An attempt to identify Phillips' Species).*" By George Robert Vine. 161

"On the Geology of Palestine." By W. H. Hudleston, M.A., F.G.S., &c.... 174

"A Glacial Deposit near Doncaster." By Thomas Hill Easterfield ... 212

"Notes on a Visit to the Channel Tunnel." By Arnold Lupton, M. Inst., C.E., F.G.S., &c. 213

"On the Sequence of the Permian Rocks, near Ripon." By the Rev. J. S. Tute, B.A. 218

"Some Indications of a Raised Beach at Redcar." By the Rev. J. S. Tute, B.A. 220

"On the Raised Beaches on the North-East Coast of Yorkshire." By W. Y. Veitch, Esq., M.D. 221

"Notes on the Carboniferous Entomostraca and Foraminifera of the North Yorkshire Shales." By George Robert Vine 226

"Glacial Sections near Bridlington. Part III. The Drainage Sections." By G. W. Lamplugh. 240

"On the Shell Mounds or Kitchen Middens at Spurn Point." By H. Bendelak Hewetson. (Title only). 254

"The Young Stage of Some Carboniferous Cephalopoda." By Wm. Cash, F.G.S. (Title only). 254

"Biographical Notices of Eminent Yorkshire Geologists. II., 'Adam Sedgwick.'" By T. M'Kenny Hughes, M.A., Woodwardian Professor of Geology, Cambridge 255

"Geological Excursion to Holderness, the Kilnsea Shell Mounds, Spurn Point, and the Pile Dwellings at Ulrome." By James W. Davis, F.G.S. 269

Secretary's Report and Balance Sheet 276-280

Minutes 281

Summary of Geological Literature 285

List of Members 287

Meteorology of Bradford for 1883. By J. M'Landesborough, F.G.S., and A. E. Preston, F.G.S.

1884.

"Biographical Notices of Eminent Yorkshire Geologists. III., 'John Williamson.'" By W. C. Williamson, LL.D., F.R.S., &c., Professor of Botany at the Owen's College, Manchester. 295

"On the Mineral Wells at Harrogate." By Richard Carter, C.E., F.G.S. ... 313

"The Harrogate Wells, or the Mineral Waters of Harrogate geologically considered." By C. Fox-Strangways, F.G.S., &c., of H.M. Geological Survey. 319

"The Mineral Springs of the Grand Anticlinal of the West Riding: a few Chemico-Geological Notes." By Geo. Oliver, M.D. (Lond.) ... 336

"The Mineral Wealth of Harrogate." By R. Hayton Davis, F.C.S. ... 357

"Analysis of the Kissengen Saline Chalybeate Water, 1883, as compared with analyses in 1845, 1854, 1867, and 1879." By R. Lloyd Whiteley. Student in the Yorkshire College 366

"Contributions to the Fossil Flora of Halifax." Part IV. By Thos. Hick, B.A., B.Sc., and William Cash, F.G.S. 370

"Further Notes on New Species, and other Yorkshire Carboniferous Fossil Polyzoa described by Prof. John Phillips." By George Robert Vine 377

"On the Composition of the Coal Balls and Baum Pots in the Lower Coal Measures." By H. B. Stocks 393

"On the Fire-Damp Detector, with recent Improvements in the Miners' Safety Lamp; and some remarks on the difficulties connected with Deep Mining" By W. E. Garforth, C.E. 395

"On a new Species of Heterolepidotus from the Lias." By James W. Davis, F.G.S., &c. 403

Secretary's Report and Balance Sheet 408
Minutes 412
Summary of Geological Literature relating to Yorkshire, published during 1884, with addenda for 1880–1883 415
List of Members 417
Meteorology of Bradford for 1884. By J. McLandesborough, F.G.S., and A. E. Preston, F.G.S. 424

K

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

NEW SERIES, VOL. VIII., PART I., pp. 1 to 155.

With Five Plates.

EDITED BY JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

1882.

PROCEEDINGS OF THE YORKSHIRE
Geological and Polytechnic Society.

VOL. VIII., PART I.

WITH FIVE PLATES.

EDITED BY JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

1882.

CONTENTS.

PAPERS:— PAGE.

1. "Biographical Notices of Eminent Yorkshire Geologists, I., 'John Phillips." By the Editor. 3
2. "On the White Chalk of Yorkshire." By the Rev. E. Maule Cole, M.A., F.G.S. 21
3. "Glacial Sections near Bridlington." By G. W. Lamplugh. Part II., "Cliff Section extending 900 yards south of the Harbour." ... 27
4. "Notes on the Occurrence of Fossil Fish Remains in the Carboniferous Limestone Series of Yorkshire." By J. W. Davis, F.G.S. 39
5. "On the Lead Veins in the Neighbourhood of Skipton." By J. Ray Eddy, F.G.S. 63
6. "On the Discovery of Flint Implements on the Hills between Todmorden and Marsden." By Robert Law and James Horsfall 70
7. "Yorkshire Fossil Mollusca." By William Cash. 77
8. "On the Recent Extension of Mining Operations under the Permian Formations." By Thomas William Tew, Esq., J.P. ... 89
9. "Photograph,–Thornwick Bay, Flamborough." By G. W. Lamplugh 103
10. "On some Sections Exposed duringthe Formation of Line of the Railway between Upton and Kirk Smeaton." By James W. Davis, F.G.S. 107
11. "Notes on the Excursion to the West Riding of Yorkshire; together with Preliminary Remarks." By W. H. Hudleston, F.G.S., President of the Geologists' Association, London. 113
12. Secretary's Report and Balance Sheet. 136-140
13. Minutes. 141
14. Summary of Geological Literature. 147
15. List of Members. 149

Meteorology of Bradford for 1882, By J. McLandsborough, F.G.S., and and A. G. Preston, F.G.S.

LEEDS:
PRINTED BY A. MEGSON AND SONS, BAINES' BUILDINGS, BANK STREET.
1883.

Vol. VIII.] [Part I.

PROCEEDINGS

OF THE

YORKSHIRE

GEOLOGICAL AND POLYTECHNIC SOCIETY.

Edited by JAMES W. DAVIS, F.S.A., F.G.S., &c.

1882.

BIOGRAPHICAL NOTICES OF EMINENT YORKSHIRE GEOLOGISTS.

I. "JOHN PHILLIPS." BY THE EDITOR.

My personal knowledge of Professor John Phillips dates no further back than the meeting of the British Association at Bradford, in 1873, only one year before his death. My recollection is very fresh of his kind and genial face, his winning and encouraging smile, the ever-ready and wise words with which he brightened and enlivened the most perplexing questions, and the deep knowledge and great experience which lay below and prompted all his observations. This comparatively slight personal knowledge, however, has served to give life and vigour, an actuality which otherwise might have been impossible, to the study of the works of the veteran geologist. Within the short period of the life of John Phillips, the history of geology as a science has had its birth, has been nurtured and grown, and before his death, its interesting ramifications had encircled the whole crust of the earth. The germs of truth gathered and elucidated by Professor Phillips and his uncle, William Smith, have served as the basis on which the whole superstructure of geological science has been erected.

Before the advent of the present century, a correct knowledge of the composition of the crust of the earth had no existence. The whole aggregation of the rocks was generally imputed to the action of the deluge as defined by the Mosaic description, and the occasional discovery of the embedded fossil remains of some plant or animal was considered due to a freak of nature, an accidental representation of some living form. Such were the theories of Tertullian and Pliny in the early part of the christian era, who, accepting the results of the labours of Aristotle and his school, considered that all fossil remains were due to a plastic virtue latent in the earth, or that the slime of rivers or the mud of the earth had power to originate the animals whose forms became entombed in the rocks. It is true, that even before the time of Aristotle, there were at rare intervals philosophers, as for instance, Zenophanes (500 B.C.), and Herodotus (450 B.C.), who attributed the presence of fossil fish and shells in the quarries far away from the sea, to the fact that the rocks containing them must at some previous time have formed the bed of the sea, and that the fish and molluses died and were entombed in the soft mud. Such theories were, however, generally ridiculed. After the time of Pliny (*b.* 23 A.D.), who learnt much from the researches of the early Greeks, intervened some fourteen or fifteen centuries of almost universal darkness, during which time all knowledge suffered from the general dearth of intellect in Europe; science, art and literature being alike retrogressive and no development appearing to have been possible. During the 15th, 16th and 17th centuries, greater interest was taken in the collection of fossils, and several interesting books were written, largely illustrated with plates of specimens. This newly awakened interest was liveliest in Italy, but in this country Dr. Martin Lister contributed several articles to the Philosophical Transactions printed in the volumes for 1674 and succeeding years. He described certain stones figured like plants which he considered to be plants petrified. He also figured fossil and recent shells side by side, so that the close resemblance between the two at once became apparent, and supported his theory, that the fossils were once living animals. Altogether his work conduced much to produce a true knowledge of fossil remains. A belief gradually grew in the minds of intelligent people that the fossils represented animals which had lived at some former period, but the erroneous conviction now entertained was, that they were all carried and left in the position where they were found, by the Noachian deluge. Quite to the beginning of the nineteenth century, and even much later, the belief existed in the Mosaic account of the creation of the world in six literal days, and that the whole earth was subjected to an universal deluge by which every living thing was destroyed, except Noah and those with him in the ark. Entertaining these opinions, it is not very remarkable that all fossil remains should be identified with the flood, and that all the literature relating to geological subjects published about this time should be saturated with this belief. One or two instances of the prevalence of these opinions may be interesting:—Buffon, a natural historian of much merit, published his "Theory of the Earth" in 1749. In this work he discussed many important geological questions, touching the action of natural causes in wearing down the land, and the gradual interchange of position between sea and land. Soon after the appearance of his work he received a polite intimation from the Faculty of Theology, in Paris, that there were several propositions in his book which were reprehensible and contrary to the creed of the Church; he was invited to present himself and recant. Not feeling in any way bound to suffer as a martyr to science he drew up the following declaration, which he was required to publish. "I declare that I had no intention to contradict the text of Scripture; that I believe most firmly all therein related about the creation, both as to order of time and matter of fact; and I abandon everything in my book respecting the formation of the earth, and, generally, all which may be contrary to the narration of Moses."

In 1731, Professor Scheuchzer, a Swiss naturalist, discovered some bones which he described as those of a child destroyed by the deluge. He also found two vertebræ, which he attributed to another individual of gigantic size of the same race. The belief being thereby strengthened in the huge size as well as long life of our progenitors—both probably equally incorrect. Engravings of both these were subsequently given in the "Copper Bible." Cuvier afterwards examined these interesting relics and pronounced the skeleton of the supposed child to be the remains of a gigantic salamander, and the two vertebræ to be those of an ichthyosaurus!

During the latter part of the eighteenth century and early in the present one, William Smith, uncle of John Phillips, made a series of distinct and remarkable discoveries, which served in a few years to revolutionize and place on a truly scientific basis the whole theory of geological knowledge.

William Smith was a land surveyor and engineer, and whilst engaged in his professional labours he had repeated opportunities of studying the surface of the land in various parts of the country. Having become well acquainted with the series of oolitic rocks in the neighbourhood of Bath, his native place, he discovered that each separate stratum of rock or clay had its peculiar system of fossils, many of which were quite characteristic of the bed in which they were found and did not extend to those above or below. After fully maturing his conception of this fact, business called him to Yorkshire, and here he had opportunities of observing that the same fossil shells, etc., which characterized the strata near Bath also occurred in similar beds of limestone or sandstone in this county, and are equally certain in their distribution. Repeated visits to various parts of the country convinced Smith that his generalizations applied to all parts; and resulted, after many years of hard and patient labour, in a geological map of the strata of England and Wales, which was followed by more detailed maps of many of the counties. He also tabulated the whole series of strata occurring in England and Wales with the characteristic fossils of each section of the rocks. William Smith did immense service to the science by clearly demonstrating:—I. That the strata wherever present always occupy the same relative position. II. That the strata have been deposited at successive periods beneath water; and that the fossils found in them were the remains of organisms that lived in those waters, and were afterwards imbedded in the sand or mud and became fossil. III. That particular species of organic remains are limited to particular strata.

It is difficult at this day to realize the great importance of these discoveries. Before "Strata Smith," as he came to be familiarly known, had discovered by his painstaking and self-abnegating researches, that there was order and regularity in the arrangement of the strata composing the earth's surface, every phenomenon, whether with respect to the rocks or their fossil contents, was attributed to the action of the deluge. Scientific men of that day, as now, differed in matters of detail, but as regards the primary proposition, there were few instances where minds of strong calibre resisted the superstitious influence of the age, and made as in the instance of Buffon, even a few steps towards the great truth realized by William Smith. Practical miners and quarrymen certainly saw that there was an alternation of strata in the rocks through which they pierced, but that they were persistent over large areas, or that the strata were arranged in a regular consecutive order, were circumstances of which they had no conception. The work of Smith demonstrated all this, and laid a true basis for a correct knowledge of the principles which underlie all geological facts. He traced the extension of the oolites and lias from the Midland Counties into Yorkshire. The older rocks of the Welsh Mountains were found to be similar to those of Westmoreland and Scotland. The relations of the various coal fields, of the old red of Scotland and of Devonshire, and all the intermediate beds, were mapped and defined. In the short space of one man's life he mapped the whole of England, and published twenty-six county maps beside: forming a striking contrast to the amount of work done by the Geological Survey of the present day. The manufacturing and mining districts of the

West Riding have been surveyed for several years and still there are only about one half the sheets of the map of this important area issued at the present moment.

The vast work of Smith was readily appreciated by his brethren of the hammer. In 1807 the Geological Society of London was formed and took a position, which it maintains still, of the foremost organization in the world for the cultivation, recognition and dissemination of geological knowledge. Amongst the founders and early members of the Society were, Buckland, who investigated the Kirkdale Caves, in Yorkshire; Adam Sedgwick, who was born at Dent, and a thorough Yorkshireman; Vernon Harcourt—Charles Lyell, Phillips, Murchison, and many others whose names are revered as the pioneers in the science, though they have passed away. These *savans*, heartily recognizing the truth of the discoveries of Smith, advanced them, not only in this country but quickly bore them over the continent of Europe and to Asia and America. Everywhere the same evidence was afforded that the rocks composing the whole surface of the earth are the result of ever-acting causes, that the ordinary and common denuding agencies of rain, frost, and ice, gradually but incessantly grind down the surface of the earth, the disintegrated material being borne by rivers to the sea, there again to be deposited and in time raise up new lands. Such were the forces found to be now at work, and to be those on which a reasonable basis could be laid to explain long past accumulations of stratified rocks.

Fortunately, an account of Professor Phillips' early life written by his own hand, has been preserved in the "Athenæum" newspaper for May 2nd, 1874. From it we learn that he was born on Christmas Day, 1800, at Marden, in Wiltshire. His father, the youngest son of a Welsh family settled for many generations on their own property at Blaen-y-ddol, in Carmarthenshire, was trained for the Church in which some of his relatives had place; but this plan was not carried out. "He came to England, was appointed an officer of Excise, and married the sister of dear old

William Smith, of Churchill, in Oxfordshire. His father died when Phillips was seven years old, his mother soon after ; and from that time he was under the charge of his uncle, a civil engineer in full practise, known as "Strata Smith."

At ten years of age, John Phillips was at a school at Holt-Spa, in Wiltshire, where a small microscope was given to him, and he speaks of the delight with which all natural objects were scrutinized by its magnifiers; he appears also to have been fond of athletic exercises, for he says, "When you see me now (χαλεπῶς βαδιζων) tired with the ascent of Geo Fell and the rough path of the Zmutt Glacier, you will hardly credit me as the winner of many a race, and the first in many a desperate leap. My work at this school was incessant for five years. I took the greatest delight in latin, french and mathematics, and had the usual lessons in drawing. We were required to write a good deal of latin, especially our Sunday theme ; of such, I wrote many for my idle associates. I worked through Mole's algebra and Simson's Euclid, the first two books completely, and selections from the others. The French master was a charming old Abbé, a refugee, whose patience and good nature and perseverance were quite above praise. We spoke and wrote french in abundance. Of greek I learned merely the rudiments, to be expanded in after life. I did not work at german until some years later ; italian I merely looked at."

On leaving school, Phillips accepted a twelve months invitation to the home of his ever-honoured friend, the Rev. Benjamin Richardson, of Farleigh Castle, "One of the best naturalists in the West of England, a man of excellent education, and a certain generosity of mind, very rare and very precious. Educated in Christ Church, he retained much of the indefinable air of a gentleman of old Oxford ; but mixed with this, there was a singular attachment to rural life and farming operations. Looking back through the vista of half a century, among the ranks of many kind and accomplished friends, I find no such man ; and to my daily and hourly intercourse with him, to his talk on plants, shells and fossils, to his curiously rich old library, and sympathy with all good knowledge I may justly attribute whatever may be thought to have been my own success in following pursuits which he opened to my mind."

From the rectory of Farleigh, John Phillips returned to his uncle Smith, whose house overlooked the Thames from Buckingham Street. William Smith at this time was in the exercise of a lucrative and honourable profession; he had for many years been at work on his great "Map of the Strata of England and Wales," which was published in 1815. "His home was full of maps, sections, models and collections of fossils; and his hourly talk was of the laws of stratification, the succession of organic life, the practical value of geology; its importance in agriculture, engineering and commerce; its connection with physical geography, the occupations of different people, and the distribution of different races. In this happy dream of the future expansion of geology, his actual professional work was forgotten, until at length he had thrown into the gulf of the strata all his little patrimony and all his little gains, and he gave up his London residence, and wandered at his own sweet will among those rocks which had been so fatal to his prosperity, though so favourable to his renown." In all the pursuits and cares of his uncle, John Phillips had his share; they were never separated in act or thought, and so his mind came to be moulded on that of his uncle.

In 1824, they accepted an invitation to give a course of lectures on geology at York, and from that time Phillips was constantly engaged in Yorkshire to give lectures and arrange museums, and many valuable friendships were created in its several towns; thus "the great county, in which thirty thoughtful years were afterwards passed, became known to me as probably to no others. The generous Yorkshire people gave no stinted remuneration for my efforts to be useful; and I employed freely all the funds which came to my hands in acquiring new and strengthening old knowledge, so as to be able to offer instruction in almost any department of nature, but especially in zoology and geology." At York he became associated with Mr. W. V. Harcourt, the first president of the Yorkshire Philosophical Society, and they along with Brewster, Forbes, Johnson, Murchison and Daubeny, were the principal means of organizing the British Association for the Advancement of Science. Professor Phillips concludes his short autobiography with the following sentence.—" Educated in no college, I have professed geology in three Universities, and in each have found this branch of science firmly supported by scholars, philosophers and divines."

We have considered, however briefly, the state of knowledge of the earth's crust anterior to the commencement of the present century. The exploded belief in the all-powerful energy and widely ranging results of the deluge gave place to an earnest endeavour by all scientists to collect and chronicle the fossil contents of the various strata. Cuvier did immense service in the tertiary beds of the Paris basin amongst the higher forms of animal life, and was worthily followed by his pupil Louis Agassiz, whose knowledge of recent and fossil fishes led him to perceive a succession in the forms deposited in the earliest rocks and ranging up to the present time, which bears some correspondence to the developmental stages of modern fishes. Professor Agassiz in this country found a fellow-worker amongst the fossil fishes, in Sir Philip Egerton, whose ichthyological contributions to scientific literature have been both important and extensive. Sowerby, Owen, Morris, Forbes and many others were collecting and describing fossils from the British rocks. John Phillips was not idle, in addition to his many other published works about this period, and all his lecturing and arranging museums, he published (1829—1836) his " Illustrations of the Geology of Yorkshire," in two quarto volumes, which beside the stratigraphical descriptions of the northern and eastern divisions of the county, contained descriptions and figures of hundreds of species of fossils, ranging over the whole series of the animal kingdom comprised in the strata between the silurian rocks of Howgill Fells and the secondary and tertiary series on the south eastern coast. In connection with the Geological Survey, he also produced in 1843, his work on the "Palæozoic Fossils of Cornwall, Devonshire and West Somerset," which contained an equal or larger amount of original matter in connection with fossil remains. The result of all this activity in every part of the world was very great; more than 30,000 species of fossils were named, described, and in many cases figured. The fossils were found to be far larger in number than the living forms, and many of them were ascertained to be without any living representative; others, found almost in the earliest rocks have existed through the untold ages since their first appearance and are still represented in the seas of the present day.

The varied picture presented to a careful and enquiring mind by the consideration of this subject is one of profound and awe-inspiring interest. It opens up a large field for speculation; and its bearing on the past history of the globe and its inhabitants is of the utmost importance.

Geology, as a science, is pre-eminently one of facts, and unless its truths are treasured and adhered to, speculations and generalizations, which of necessity must be interwoven with those facts, may prove not only misleading, but injurious. So long, however, as the imagination is chained down to a basis of truth, and a solid foundation of indubitable and thoroughly well digested knowledge serves to leaven the edifice, the superstructure of inference and deduction may be both correct, pleasing and highly instructive. Without the use of the imagination to fill in the pictures presented by a study of the fossils found in the rocks, of ages and periods long past, whose similitudes can never recur, geological as well as other science, would only prove barren and abortive. For example:—the fossil remains of some fish, or shell, or plant are found imbedded in the shales of the coal measures; the whole of the original matter composing the bones of the fish or the tissues of the plant have been removed, and in their place is a wonderfully well-preserved *fac-simile*, in all probability composed of the same material as the surrounding masses of shale. The structure which characterized the objects when living is retained with exquisite perfection, and the highest powers of the microscope only serve to expose the infinite exactness of this mineral reproduction. These are the facts: the inferences to be drawn from them are many. They call into operation a wonderful play of the highest powers of the human mind. All kinds of collateral sciences are brought to bear in the elucidation of the problems suggested by these facts. Zoology, by comparison with existing forms, enables us to ascertain, with more or less correctness, the nature and habits of the fossil fish, the shape and character of its teeth, its covering of dermal armature and the presence or absence of external means of offence, thus affording data on which may be based assumptions as to the character of its food and the necessity or otherwise for protection against powerful foes. The changes undergone by the fossil since it first sank to the mud at the bottom of the water, call in the aid of chemistry and mineralogy. Possibly the structure of the fish may give valuable insight into its habitat when living, as to whether it was a denizen of salt, estuarine, or fresh water, and thus, much knowledge may be gained as to the physical geography of the land and sea, and the method of aggregation of the strata deposited during that period of the world's history. A similar course of reasoning may also be applied to the fossil shell or plant.

The great accumulation of geological and palæontological facts, led a few years later on, to a number of theoretical generalizations which exercised the greatest scientific minds of this or probably any previous age. The stratagraphical knowledge accumulated by William Smith and his followers not only laid the foundation for geological science in this country, but the influence of their labours spread over a great part of the civilized world, the methods of research and the nomenclature used by British geologists having been adopted in every other country as a foundation whereon to base local and minor designations. Philosophers speedily collated their knowledge and proceeded to adapt it to already existing theories, or new ones were originated to account rationally for the phenomena of nature during the long past ages. Professor Phillips wrote in 1837,* "From a mass of crude speculations fitted to inaccurate observations, it (*i.e.* geology) has gradually grown up to a system of sound, though limited inferences, connected by some very probable generalizations, and supported by independent mathematical reasoning. The *laws of phenomena* are unfolded to a considerable extent, and in the opinion of eminent men of science, the time is at hand for effectual researches into the *laws of causation.* Not that the labours of observation should, for an instant, be suspended; *they* are the most important of all the means of advancing geology; on the contrary, they ought to be continually excited by new impulses, and turned into more profitable directions by the first, however rude, indications of theory. The state of geology is so prosperous, that its numerous cultivators may well agree to divide their forces so as to accomplish combined movements; to advance on the one hand, the mass of generalized phenomena, and on the other, to multiply the points of contact between dynamical, chemical and vital laws and the results of geological inquiry."

It would be impossible within the limits of this paper to trace the various theories which have finally resulted in the great work of Darwin on the Development of Species by Natural Selection. It is a little more than twenty-one years since the "Origin of Species" was issued from the press, and in that short period the work has created a complete revolution in all modern scientific thought. It is not to be supposed that the origin of this great discovery rested solely with Darwin: many minds had been working at the problem. It was the natural outcome of all the accumulated thought for years previously, and solved the problem which was the great stumbling-block to all advance. The belief in "special creations" had long been undermined by well established facts, and many naturalists were convinced that development or evolution was the true explanation of the origin of all the multitude of species which do now, and have in times past, peopled the earth; but to Darwin was reserved the grand discovery of natural selection and descent with modification. The many and important results of these researches may be briefly stated as follows. That all life is the result of development from pre-existing forms, and adaptation to the circumstances under which it exists; and, as Mr. Spencer has aptly termed it, "the survival of the fittest." A most important result of the theory is the present widely extended belief in the antiquity of man. The limited period of 6,000 years is now proved to be totally inadequate. The remains of man have been repeatedly found in association with extinct animals, both in Yorkshire and in all parts of the world. In the gravels of the Somme Valley, the Kjokkenmodding of Denmark and Sweden and the Lake dwellings of Switzerland, the worked and carved tools of the old inhabitants have been found. It is possible, nay probable, that man was in existence prior to the last so-called glacial epoch and descends even to the tertiary strata; if this be so, the age of man on the earth will of necessity be carried back much further than the few thousands of years assigned to him.

---

* Treatise on Geology, by John Phillips, F.R.S., &c., 1837.

During the year following the publication of Darwin's "Origin of Species," Professor Phillips wrote his book, entitled "Life on the Earth, its origin and succession," in which he attempted to show the fallacy of Darwin's investigations. His arguments were derived principally from want of distinct evidence of the actual transmission of some peculiarity in the fossil forms. The several animals or plants existing fossilized in the rocks certainly exhibited great advances in structure and organization over those found in strata of greater antiquity, but the connecting links had not been discovered, and Professor Phillips, like most other people, was much inclined to consider all the several forms as independent creations. After reviewing in detail the difficulties attendant on the development of a higher form from a lower, Professor Phillips continues,* "If it is not possible in the existing ocean, among the innumerable and variable radiated, amorphozoan and foraminiferous animals, to construct one chain of easily graduated life, from the fertile cell to the prolific ovarium and digestive stomach, it must be quite vain to look for such evidence in the fossil state. In the face of the assumption requisite to imagine such a chain, we cannot venture to adopt it as a probable hypothesis, and thus the idea of one general oceanic germ of life, whether we like it or not, must be abandoned. Reasoning of the same kind will convince us that to derive by any probable steps any one great division of the animal kingdom from another, involves too much hazardous assumption to be adopted by a prudent inquirer."

From this extract it is clear that to the mind of Professor Phillips, in 1860, the difficulties in connection with the acceptance of Darwin's theory of evolution quite outweighed the simplicity and beauty of the conception, and he felt bound to reject it. But in the short space of a dozen years, the labours of many naturalists, in most cases equally unbelieving, had produced such a mass of confirmatory evidence, that the theory is now generally accepted by the scientific workers of every country.

The researches of Professor Huxley have demonstrated the close relationship between birds and reptiles. American palæontologists have discovered a series of fossil remains of animals which exhibit, in a no less clear than marvellous manner, the history of the ancestry of the horse from an animal little larger than a dog; this little animal, in some respects very different in structure to the horse, is found to have been slowly changed, step by step, through the successive stages of later geological time, until the noble quadruped, so useful, nay, indispensable to man, has been the result. The feline animals have also been shown to have had distant relations, during the tertiary period in the carniverous animals, *e.g.* Dinictis, Machœrodus and others, whose remains are found buried in those deposits. Much has been learnt respecting the ancestry of living fishes and of many of the, so-called, lower forms of life. Space will not permit that these instances should be more than alluded to at present. But they serve to illustrate one of the brightest characteristics of a mind trained to scientific methods, and pre-eminently such an one was that of John Phillips. A year or two after the publication of his friend Darwin's work, he had, after mature reflection opposed the whole theory; but in 1873, at the meeting of the British Association at Bradford, the ever-increasing mass of evidence in favour of natural selection and development had produced their natural result, and we find the Professor in his presidential address to the geological section discoursing as follows*:—"But concurrently with the apparent perpetuity of similar forms and ways of life another general idea comes into notice. No two plants are more than alike; no two men have more than a family resemblance; the offspring is not in all respects an exact copy of the parent. A general reference to some earlier type accompanied by special diversity in every case ('descent with modification') is recognised in the case of every living being.

---

* Life on the Earth, p. 211. 1860.

"Similitude, not identity, is the effect of natural agencies in the continuation of life forms, the small differences from identity being due to limited physical conditions, in harmony with the general law that organic structures are adapted to the exigencies of being. Moreover, the structures are adaptable to new conditions; if the conditions change, the structures change also, but not suddenly; the plant or animal may survive in presence of slowly altered circumstances, but must perish under critical inversions. These adaptations, so necessary to the preservation of a race; are they restricted within narrow limits? or is it possible that in the course of long-enduring time, step by step and grain by grain, one form of life can be changed, amd has been changed to another, and adapted to fulfil quite different functions? Is it thus that innumerable forms of plants and animals have been 'developed' in the course of ages upon ages from a few original types?

---

* Brit. Assoc. Report, 1873. Trans. of the Sections, pp. 73, 74.

"This question of development might be safely left to the prudent researches of physiology and anatomy, were it not the case that palæontology furnishes a vast range of evidence on the real succession in time of organic structures, which on the whole indicate more and more variety and adaptation, and in certain aspects a growing advance in the energies of life. Thus at first only invertebrate animals appear in the catalogues of the inhabitants of the sea; then fishes are added, and reptiles and the higher vertebrata succeed; man comes at last to contemplate and in some degree to govern the whole.

"The various hypothetical threads by which many good naturalists hoped to unite the countless facts of biological change into a harmonious system have culminated in Darwinism, which takes for its basis the facts already stated, and proposes to explain the analogies of organic structures by reference to a common origin, and their differences to small, mostly congenital, modifications which are integrated in particular directions by external physical conditions, involving a 'struggle for existence.' Geology is interested in the question of development, and in the particular exposition of it by the great naturalist whose name it bears, because it alone possesses the history of the development *in time*, and it is to inconceivably long periods of time, and to the accumulated effect of small but almost infinitely numerous changes in certain directions, that the full effect of the transformations is attributed.

"For us therefore, at present it is to collect with fidelity the evidence which our researches must certainly yield, to trace the relation of forms to time generally, and physical conditions locally, to determine the life periods of species, genera and families in different regions, to consider the cases of temporary interruption and occasional recurrence of races, and how far by uniting the results obtained in different regions the alleged 'imperfection of the geological record' can be remedied."

I have, perhaps, dwelt longer on the important question of Darwinism than the nature of my subject will warrant, but it is one of such vital importance to the success of all future work in the natural history of living or fossil animals and plants, that I trust I shall be excused; and the experience of Professor Phillips may serve a very useful purpose if it teaches us the lesson of patience and forbearance in passing judgment on what may, in the first instance, be thought extraordinary or even ridiculous theories, but which may eventually be proved to be founded on just and right principles, the result of life-long thought and experiment.

In 1828, John Phillips was elected a Fellow of the Geological Society, and six years later, when 34 years of age, he was chosen as the Professor of Geology at King's College, London, and also a Fellow of the Royal Society. Ten years later again, in 1844, he became the Professor of Geology at Trinity College, Dublin. During this period he was working at several branches of science in addition to geology. He made very valuable observations in meteorology, a science at that time little understood or appreciated. Astronomy also received some attention, and several papers on the planet Mars and other subjects are printed in the Proceedings of the Royal Society. As already stated, Phillips played an important part in organizing and managing the British Association; for many years he was the secretary, and the first twenty-seven volumes of its proceedings were produced under his editorship. In 1859 and '60, he was president of the Geological Society, and in 1865 of the British Association. Meanwhile he had taken the place of Dr. Buckland as Professor of Geology at Oxford, a position which he held during the remainder of his life.

Professor Phillips was an indefatigable worker. He never tired in his efforts to spread abroad that love of nature which so thoroughly imbued his own existence. By example and teaching, whether orally or with the pen, his single aim was the advancement of those branches of knowledge which had proved so ennobling to his own existence. Never married, he was wedded to his science, and in all his labours, whether as an original investigator, an organizer of the means for encouragement and assistance of his fellow-workers, or more important than either, as an inculcator of a true knowledge and love of scientific method in the youthful minds of those entrusted to his care at the college or elsewhere,—he was always earnest and sincere.

No one would endorse more heartily than Phillips the noble words of a recent speaker, with which I will conclude this sketch, with the substitution of one word; they are as follows:—"The benefit to the student of *science* flows from the improvement of his own mind; from the exercise and expansion of his power to perceive and to reflect; from the formation of habits of attention and application; from a bias given to character in favour of cultivating intelligence for its own sake, as well as for the sake of the direct advantages it brings. The advantages lie in the far future, and do not administer to the feverish excitement which are of necessity in the various degrees incidental to the pursuits of the modern commercial world. The habits of mind formed by *Scientific pursuits* are founded on sobriety and tranquility; they help to settle the spirits of a man, fixing them upon the centre of gravity; they tend to self-command, self-government, and that genuine self-respect which has nothing in it of self-worship. It is one thing to plough and sow with the expectation of the harvest in due season when the year shall have come round; it is another to ransack the ground in a gold-field with the heated hope and craving for vast returns to-morrow or to-day. All honour then to *Science*, because, while it prepares young men in the most useful manner for the practical purposes of life, it embodies a protest against the excessive dominion of craving appetites, and supplies a powerful agency for neutralizing the specific dangers of this age."

ON THE WHITE CHALK OF YORKSHIRE. BY REV. E. MAULE COLE, M.A., F.G.S.

THE following notes are supplementary to the papers already published on the Red Chalk (1878), and on the origin and formation of the Wold Dales (1879.)

The white chalk of Yorkshire differs considerably from the chalk of Kent and Sussex. In the first place, it is much harder, and in places almost crystalline. Then, the flint-bearing beds are the lowest in the Yorkshire series, whereas they are the highest in the southern; the upper beds in Yorkshire, forming the inner edge of the Wolds, have not a trace of flint. The flints too are different; in the north they are light-coloured and can be shattered by a blow into a thousand pieces, whilst in the south they are black, tough, hard, and compact.

Numerous flint weapons, knives, arrow-heads, spear-heads, scrapers, &c., have been picked up on the surface of the Wolds, or extracted from the numerous tumuli, but they are almost invariably of foreign flint picked up probably on the sea shore, washed out of the Boulder Clay, the flint of Yorkshire not being adapted for the manufacture of flint weapons.

A Frenchman, Mons. Barrois has attempted to divide the Chalk beds into a series of zones, containing characteristic fossils, but enough attention has not yet been paid to the subject, in Yorkshire at least, to prove or disprove the truth of his theory.

It is certain, however, that very large *ammonites* are only found in the lower beds, and *marsupites* only in the highest, whilst on one horizon *inocerami* are very plentiful, and on another scarcely any fossils are found at all. So far this favors his views.

The chalk itself is very variable. Sometimes it is quite slaty, and splits up into thin layers; sometimes it occurs in massive beds without a trace of parting. Wherever a parting occurs there is almost always found a thin deposit of fuller's earth, which seems to have been the primary cause of the non-coherence of the layers above and below; sometimes as many as twenty of these partings will occur in one or two inches of chalk, dividing it into as many thin plates. On the other hand, layers of fuller's earth from one to three inches thick are occasionally found, and also beds of chalk one or two feet thick, without any parting at all.

Where masses of chalk have been rolled about on the sea shore and rounded, remarkable wavy lines like the sutures of a skull, may be traced on the surface. These are due to extremely fine layers of fuller's earth. We call it "fuller's earth" for lack of a better word, but it seems to have been a fine sediment of mud, deposited over the ocean floor as the chalk was accumulating, representing a certain amount of denudation carried on by the waves, much the same as the lagoons of coral atolls in the Pacific receive muddy deposits from the disintegration of the reefs.

If this idea is correct, it follows that chalk was not deposited in a deep sea, as once supposed, but in comparatively shallow waters, where coral reefs existed in all directions, with no neighbouring land, and no rivers bringing down sand and muddy impurities to stain the pure whiteness of the chalk.

This peculiar rock is doubtless composed largely of the calcareous skeletons of foraminifera which swarmed in the warm waters, which then covered Central Europe, much the same as they now contribute to the formation of the grey ooze of the Atlantic, but the formation of chalk was probably greatly accelerated by the disintegration of coral reefs, which, in the form of minute calcareous sediment, would assist in the accumulation of the beds known as Chalk.

The chalk area extends, with occasional breaks from Ireland to the Crimea, and from Sweden to the Pyrenees. It is absurd to suppose that this area ever formed a *deep* sea. Continents grow like everything else, and materials from the land, brought down by rivers and carried out to sea, are invariably deposited within about 150 miles of the shore line. Europe had certainly attained a continental form long before the deposition of the chalk, and there is no reason to suppose that a *deep* sea, such as the Atlantic, occupied its area in cretaceous times. It is more probable that a slight depression allowed the waters of the Atlantic to pour over its central portion, the constant flow, eastwards, of a stream similar to the present Gulf Stream, supplying an enormous quantity of foraminifera, which, by their decay, aided by the disintegration of coral reefs, caused the accumulation of calcareous sediment known as chalk.

It may be added that the fossils found in chalk, are indicative of animal life, existing not in deep, but shallow water.

The beds of chalk which constitute the Wolds dip in various directions, owing probably to irregularities of pressure or compression in the process of elevation, but the general dip of the whole semicircular mass is in the direction of a central point somewhere about Hornsea, consequently the beds on the N. ridge running from Acklam to Speeton dip southwards, whilst the beds on the W. ridge from Acklam to Hessle dip eastwards. The base of the chalk is met with all round the N. and W. edges at varying elevations, marked by the line of springs, (*vide* Red Chalk, 1878).

As a rule the higher the hills, the thinner the chalk. But the very fact of the chalk being thin, at most 200 feet on high elevations, shows that we are in the lower flint-bearing beds all round the N. and W. area, whilst we only reach the upper beds without flints on the inner and lower circle of ground, seawards.

A line drawn from the S. landing at Flambro' Head through Burton Agnes, Kilham, Cottam Warren to Life Hill, Sledmere, on the one hand, and from thence south through Wetwang, Tibthorpe, and Leckonfield, to the Westwood pits at Beverley, will separate the two areas of flint-bearing and nonflint-bearing chalk; that to the N. and W. containing flints, that to the S. and E. apparently without. A reference to the numerous chalk pits all over the country, will confirm this statement, but it is also proved by the presence or absence of flints on the surface of the ploughed fields. Chalk readily decays under atmospheric denudation, but not so flints. Hence, wherever the subsoil contains flints, they rapidly accumulate on the surface, and sometimes have to be picked off by hand.

We have spoken of flints as if they were all alike, but this is not the case, there are "flints and flints" according to the French proverb, in fact the different kinds of flints are so persistent over different areas, that they are useful in classifying and identifying zones of chalk, even without the help of fossils. For instance, in the lower beds, just above the Grey Chalk, the flints are *nodular*. This term however does not adequately describe the peculiar shape, so we must coin a word "finger-like" meaning thereby that the flints are rounded, tapering, resembling in appearance a thumb or fingers; another feature to be noticed is that unlike other flints, these are mostly found in a vertical or upright posítion. Good examples may be met with in the railway cutting immediately facing Burdale station.

In the slaty beds of chalk, which succeed next in order, the flints, as might perhaps be expected, appear in thin horizontal slices here and there.

Next above these are found *tabular* flints, *i.e.* solid compact beds of flint, of variable thickness, extending over a large area. On the sea coast, at the N. side of Flambro' Head, the setabular beds present level, but pitted surfaces, many yards in diameter, which have resisted the denudation of the waves, whilst the chalk which once covered them has long since been removed. In the interior, a fine example, 9 inches thick, has been exposed in a quarry on the top of the hill, between Fimber Station and Sledmere, by the roadside.

In the higher beds of the flint-bearing chalk, occur large angular masses of flint, partaking partly of the tabular, partly of the nodular form, of great thickness, but not wholly composed of flint; that is to say, streaks and patches of chalk are imbedded in the flint. Examples may be seen in several quarries in a straight line between Wetwang, North Dalton, and Middleton. This horizon is styled by Mr. Blake (Proceedings, Geol. Association, Jan. 1878) the "Zone of *immature* flints". He considers, it seems, that the process of the development of flint was arrested by the elevation of the chalk, and removal of pressure. It may be so, but the whole question of the formation of flint in chalk is still *sub judice.*

Above these last lies the flintless chalk, but curious to say, though there are no flints, the chalk, on analysis, yields nearly twice as much silica as the chalk which has flint. The silica seems to be dispersed throughout the mass, instead of being aggregated in tabular or nodular patches.

Now what is the origin of all these various forms of flint, including the huge "paramoudra" or "potstones" which are met with in the cliff at Flambro' and Speeton, 3 to 4 feet in height, and 1 to 2 feet in diameter?

One thing is clear, that, in a large majority of cases, they represent a mass of silica, which, by attraction or affinity, has been absorbed from the sea water which contains a quantity of silica in solution, round a nucleus of some decaying animal or vegetable.

Siliceous sponges, whose nutrition is contained wholly in the seawater, which passes through their pores, naturally form a basis for the accumulation of flint, and accordingly we find many flints bearing the exact shape of cup-shaped zoophytes, such as *spongites* and *ventriculites.* But in addition we not unfrequently find such a form as an Echinus, or "Sea Egg" completely transformed into flint, the external rays being as clearly delineated on the surface, as in the living specimens. Here, the decaying animal was evidently replaced atom by atom by silica.

The foregoing observations, meagre as they are, do not account for the large masses of *tabular* flint, though they may help to explain the origin of *nodular* flints. What can we say more? only this, that just as *calcareous* foraminifera are contributing by their decay to form the ooze of the Atlantic, as, in times gone by, they mainly formed the Chalk, so another class of life, the *siliceous* diatoms are busily engaged, at great depths, in secreting flint. Hence these may possibly form beds of flint.

But it cannot be denied that this is an unsatisfactory explanation, for beds of tabular flint occur in the middle of the chalk, deposited, as presumed above, at no great depth. Bearing, however, the fact in mind, that flint may be formed during the decay of vegetable matter, may it not be that *tabular* flints mark areas of greater or less extent, where masses of dead seaweed were accumulated?

The only argument to be urged against this hypothesis is, that dead seaweed is mostly washed up on a shore line. But what, if these areas were shore lines, or, in other words, surfaces of coral reefs? and what know we how much may settle at moderate depths out at sea? our contention throughout being that chalk was not formed in a deep, but in a shallow sea.

A word more must be added on *banded* flints; banded flints are not infrequent in the chalk. They resemble agates in showing concentric rings of silica of different alternate colours, and clearly point to a nucleus of attraction, round which layers of flint accumulated, much the same as stalactites are formed by successive coatings of liberated carbonate of lime.

At the recent meeting of the British Association at York, (1881) bottles containing silica in gelatinous forms, into which certain solutions of metallic salts had been introduced, were exhibited, showing in a beautiful manner how, in course of time, agates and banded flints *might* be produced, but the difficulty presented itself at once, that silica in a gelatinous form is not known to exist in nature, and that, for the formations in question, we must seek not for an artificial, but for a natural process of development.

In conclusion, we wish to draw attention to certain remarkable needle-shaped structures, which occur all over the chalk area of Yorkshire, but not apparently in the South of England, and which are to be met with immediately below and above the thin layers of fuller's earth, alluded to above, as interfering with the coherence of the chalk. They have been called "slickensides" by men of repute, not intimately acquainted however, with the phenomena—but they are *not* slickensides; and a thorough examination will prove convincingly that some other explanation must be sought. Either they mark an incipient form of crystalization, or they are the remaining traces of some low form of animal life of the coral type, which was arrested in its growth by the muddy deposits of fuller's earth, and began its work again as soon as the water was once more clear.

This is a question which deserves further attention in describing the Chalk of Yorkshire.

GLACIAL SECTIONS NEAR BRIDLINGTON. BY G. W. LAMPLUGH.

PART II. CLIFF SECTION EXTENDING 900 YARDS SOUTH OF THE HARBOUR.

IN pursuance of my plan of describing sections in this neighbourhood which are likely to be closed to the geologist, it is desirable that some account should be given of the cliff-section which lies immediately to the south of the Harbour at Bridlington Quay, as this is already partly hidden. I have therefore drawn to scale a section of the cliff for a distance of 900 yards from the South Pier, as is shown in the accompanying plate, and this I now supplement, as before, with a description and notes of some deductions I have drawn whilst at work on the section.

Over the extent covered by my section and for about 500 yards beyond it, a private individual, the owner of the land abutting on the cliff, has obtained foreshore rights from the Board of Trade, with the avowed intention of reclaiming and defending his property by the erection of a long line of sea-defences. As a first instalment of this work, a concrete wall was commenced four years ago near the South Pier, and carried across the beach for a distance of 750 feet; but having been based on a soft laminated clay, (No. 4 of section), its foundations have slipped upwards and outwards in places; and it is now in a very unsatisfactory condition. I suppose it is owing to this cause that the work has been suspended.

The waste of the cliff along this section has always been very rapid, but since the wall was built, the sea has encroached still faster on the cliff beyond; so that while the recession of the beach-line between 1852, when the Ordnance Survey was carried out, and 1872, in twenty years, was 220 feet, the recession since then, that is, in ten years, has been 150 feet. The actual loss in thirty years on this small estate with an exposed frontage to the shore of 1,200 yards, has been about 26 acres. The sea is swiftly bringing about a final settlement of the land question in Holderness.

That part of the accompanying section which is now hidden by the new wall is from a sketch I made of the cliff in 1877, just before the building commenced; the exposed part I have more carefully planned this autumn.

On comparing this section with the one I published last year of the cliff to the north of the town, great differences will be observed in the beds above the Purple Clay. These I shall not now attempt to explain, but as I have got a full series of sections and notes from the deep drainage works which have just been carried out in the town, and as these extend from one side of the town to the other, I expect to be able to correlate the beds; and hope next year to give my results, and thus in effect to render the sections continuous.

The cliff line runs N.E. and S.W., and as will be seen, is lowest at the northern end, being here only 28 feet above Ordnance datum. In going south there is a rather sudden rise to a height of nearly fifty feet, but the cliff begins to sink again at D in Fig. 2, where the chalky gravel puts in, and has again lost five feet of its height at the southern end of the section. Beyond this the cliff sinks regularly and very gradually for about a mile, till it disappears below the blown sands of the beach near Auburn. Northward of the section there is a slight rise, and the marls which occupy the hollow thin out. Except in this hollow, the ground sinks from the cliff edge inland.

The following beds are seen in this section:—

1. Banded fresh-water marl containing shells, plant remains, etc.
2. Small gravel, chiefly of chalk, with streaks of sand.
*2*a*. Finely laminated and ripple-marked sand and clay.
*2*b*. Disturbed glacial gravel, with sand and clay seams.
3, 3*a* and 3*b*. Dark purple boulder-clay, (THE PURPLE BOULDER CLAY), including in its midst a band of bedded boulder clay (3*c*), which admits seams of sand at B, B, B.
4. Finely laminated chocolate-coloured clay, scarcely seen in the cliff but well shown on the beach.
5. Dark greenish-blue boulder-clay (THE BASEMENT CLAY), containing many shells and shell-fragments. It nowhere rises above high-water mark in this section.

The Freshwater Marls. (No. 1). These marls are only seen at the northern end of the section, and are very similar to those on the other side of the town which I described last year,† and I believe the two join, as they seem to reach from both sides into the hollow behind the town. Their greatest thickness in this section is 7 feet. They show an irregular and intermittent seam of peat in their midst, containing remains of beetles, seeds and plants. Where thickest, their lower layers consist of gritty clay, and apparently have a tendency to pass into the underlying sand and gravel; shells are absent from this part of the bed, but there are many plant remains.

---

* I have numbered these beds somewhat arbitrarily to make the figures below agree with those in my last year's section. I do not imply there is any connection between 2 and 2*a*.

† Proc. York. Geol. and Polyt. Soc., 1881, p. 383.

Dr. Nathorst found leaves of the arctic birch *(Betula nana)* in these marls; he records his discovery as under.[*]

> "Die Suszwasserablagerung en nehmen kleine Becken in Geschiebelehm. * * * Ich in einer solchen Bildung uumittelbar am südlichen Ende der Stadt mehrere Blätter von *Betula nana L.* fand."[†]

He also doubts not that rich additions might be made from the deeper layers of these beds, and regrets he had not time to search further.[‡]

The Chalky Gravel. (2). A chalky gravel is seen directly under the fresh-water marls in Fig. 1, but is absent from the remainder of that section. What I believe to be the same gravel, however, reappears a little further south, where the cliff sinks slightly, and is much better developed. I have therefore extended my section in Fig. 2, so as to embrace its recommencement; but it is still better seen yet further south, and can be traced for above a mile, till the cliff has sunk so low as to be hidden by blown sand.

It consists of fine gravel, chiefly of chalk, with seams of sand, often showing cross-bedding. The chalk pebbles are mostly flat and sub-angular. I have examined it carefully and up to the present have found no organic remains, but think my drainage sections will show that it is of fresh-water origin. It generally rests on a highly denuded surface of the underlying sand and warp series, which is cut into deep hollows (best seen beyond the limits of my section), and it seems to be altogether unconformable to those beds. The gravel has, however, been said to dovetail[§]

---

[*] Ueber nèue Funde von fossilen Glacialplanzen. Englers botanischer Jahrbuch, 1881.

[†] "The fresh-water deposits occupy small hollows in boulder clay, * * * I found in one such bed immediately at the south end of the town, several leaves of *Betula nana, L.*"

[‡] I hope sometime to be able to follow Dr. Nathorst's suggestion and my own inclination, and to make a close examination of these marls.

[§] J. R. Dakyns, Proc. York. Geol. and Pol. Soc., 1879, p. 126.

into the sand below, and certainly in more than one place there is that appearance, but in all the cases I have examined except one, I found this appearance to be deceptive, being due to seams of sand in the cross-bedded gravel coming in contact with the underlying sand. The exception is at D in Fig. 2. where the gravel thins out; and here as the gravel is much weathered and confused, matters are not so clear.

I can give no certain information as to the manner in which the chalky gravel under the marls in the northern part of my section dies out southward, as my section of 1877 is unfortunately by no means clear on this point; at that time I confined my attention almost wholly to the boulder-clay, especially the 'Basement,' and have grouped the beds above the Purple Clay as 'clay, sand and gravel;' but from what I can gather from my notes, and from the now much obscured section, it seems to overlap the edges of the denuded sand and warp which forms the slope at C; the upper part of the sand and warp, however, contains much gravel here, and is also cross bedded. One hundred yards north of the north end of Fig. 1 a drain, which has just been cut, showed, at the surface, two feet of chalky gravel, resting directly on Purple Boulder clay. The marls had thinned out.

The Sand and Clay Series. (2a). This series, called by Prof. Phillips* 'the Warp beds,' is the chief component of the section. The upper part consists of fine yellow sand with clay partings, generally passing downward gradually into almost pure clay, in varying reddish-brown and greenish stripes; but in a few places there is a sharp line between the sand and clay. The whole series is finely laminated, and full of beautiful ripple-marking; cross-bedding is also of frequent occurrence. and in three or four places the sandy beds are crumpled and twisted in a curious manner along certain lines. This crumpling has been ascribed† in some cases, to incipient concretionary action. In the sand near C, Fig. 1, hardened root-like tubes of cemented sand, crossing the bedding, were at one time brought out by weathering; and these I looked upon as being caused by the percolation of water which had passed through the chalky gravel above, and so became charged with lime. It may be that concretionary action may be set up by the same agent, though in a few cases the crumplings look very like contortions. I give an enlarged section of a case which seems to be concretionary (3).

---

* Geology of Yorkshire, 3rd edition, p. 82.

† J. R. Dakins, Proc. Yorks. Geol. and Polyt. Soc., 1879 p. 126.

The surfaces of the clayey layers often exhibit pittings and other markings, which deserve closer study than I have yet been able to bestow.*

The division between this series and the underlying gravel is generally abrupt, but in one or two places where the gravel is thick and sandy there is a clear passage between them.

Here and there streaks and pockets of gravel appear amongst the sand and clay, and in one or two places (as at E, but chiefly to the south of my section), the beds become charged with gravel from top to bottom. Three years ago a large travelled block was to be seen† imbedded in the lower part of this division, a few hundred yards south of Fig. 2, but this is the only recorded case of the kind. I have found no organic remains either in the sand or clay.

The Lower Gravel (2b). This is a rough drift gravel, chiefly composed of pebbles and boulders washed out of the boulder-clay; but in some places it also contains in its upper part many chalk pebbles. An occasional shell-crumb may be found in it,—no more than might have been derived from the boulder-clay with the other pebbles. I have already mentioned that it sometimes passes upwards into the beds above; where this takes place it is generally thick, and sandy throughout. Downwards, its junction with the boulder clay is most irregular and peculiar. The general section and enlarged sections 1 and 2 will illustrate this better than a verbal description, and I would also refer to the account I gave last year* of very similar appearances to the north of the town.

---

* At first I was disposed to regard all these markings as rain pittings, but on one surface I examined, the pittings were arranged in definite groups of four, so that unless in the rainy days which followed the break-up of the ice, such things as symmetrical showers occasionally fell, the markings must be due to some other cause.

† Recorded by J. R. Dakyns, *supra cit.*

The Purple Boulder-Clay (3). This boulder-clay answers closely to my description of the same bed in the above-cited paper, being a dark brownish-purple clay, containing a great variety of boulders, and a few shell-fragments. The chief point of interest in this section lies in the existence of a well-stratified portion, *(3c)*, which occurs along one horizon, and thus forms a band running thread-like throughout the section.

This stratified band varies in thickness from a few inches to three feet; it does not differ much from the rest of the clay except in being bedded, but is rather more earthy, (which causes it to weather faster), and also contains a sprinkling of small chalk pebbles, and these are rare in the clay below it, and not plentiful above. It contains scratched blocks like the rest of the boulder clay, but flat pebbles are nearly always laid horizontally. The bedding is sometimes very distinct and almost fine enough to be called lamination; at others it is almost, or quite lost, though the state of the cliff has something to do with this, as it is after the washing of a heavy sea that the bedding is best brought out. There are often reddish, whitish, or greenish streaks at its base, which seem to be the remains of crushed masses of soft rocks.

Its junction with the boulder-clay below is sharply defined, but upwards it is sometimes vague. As will be seen from the section, it rests on, and follows the inequalities of, an extremely uneven surface, rising and sinking in the cliff continually, varying from about 20 feet above the beach to beach-line, and evidently lapping round and over lumpy and projecting bosses of the lower part of the clay,—passing over them sometimes at a high angle;—so that the line traced by this band in the cliff, if called a '*horizon*' is decidedly hilly in aspect.

---

* Proc. York. Geol. and Polyt. Soc., 1881, p. 384.

At the points marked B in the sections, the band passes into, or admits, seams of fine clean sand, which appear to have been sheltered under the lea of a boss of the clay-bed, as they are usually sharply cut into, and cut off, by the overlying clay. I have not yet been able to ascertain whether the direction of the leaside is *always* the same, but in two cases the sand rested on the western slope of a knoll.

Owing to the same reason as with the gravels—the deficiencies of my early section—I have not been able to trace the course of the band in the now hidden part of the section, though its continuance is indicated by the sand-seam in the midst of the clay, and I also find reference in my notes to the 'two foot seam.'

The boulder clay above the band has suffered severe and irregular erosion, being in some places 10 or 12 feet thick,—in others nearly or quite, cut through, as at F in Fig. 1. The erosion is generally deep where the peculiarly disturbed junction with the gravel (2*b*), is well developed.

Beyond the limits of my section northward, the Purple Boulder-clay, following the upward slope of the Basement Clay, comes to the surface; southward, though holding, on the whole, a slightly higher level, it rises and falls irregularly as in the section.

The Laminated Clay (4). The laminated clay on which the Purple Clay rests does not in this section, nor indeed elsewhere, rise above the level of the highest tides, and is best developed on the beach a little distance from the cliff. Its course thereon is shown by the dotted lines below the beach line in Fig. 1; these lines form a rough ground plan of the beach between tide marks.

The clay is chocolate-coloured, and very fine and tough. It is beautifully laminated, and in places ripple-marked, and contains no pebbles nor other foreign admixture, save in its lowest layers. It rests on an eroded surface of the 'Basement Clay,' which has been worn into deep hollows. Upwards, it is cut off abruptly by the Purple Clay wherever it rises much above beach level, ending thus a little beyond the limits of my section on both sides.

About 350 yards beyond the southern termination of Fig. 2, just before the laminated clay is cut out as described, it passes upward into sand with clay partings, which are in one place seven feet thick. This is only seen for a short distance; the base of the purple clay above is forced down irregularly over it, and shows slickensides. A similar sand-bed remains above the laminated clay for a short distance, on the other side of the town, and I have no doubt that sand has once been continuous at this horizon, and has nearly all been swept off during the deposition of the Purple Clay.

The laminated clay completely fills the deep and wide hollow in the Basement Clay on the beach, near the northern end of Fig. 1, so that it has here a thickness of about 16 feet: elsewhere it rarely exceeds four or five feet. The foundations of the sea-wall were placed in this hollow, with the recorded results.

There is a thin seam of chalky gravel between the laminated clay and the underlying boulder clay in the bottom of the hollow, and this, whenever tapped, yields copious supplies of very pure water, which wells out at high tide but ceases to flow at ebb. A row of piles driven down into the Basement Clay in front of the wall (with the hope of staying its further advance) forms in this way a line of fine ebbing and flowing springs; and an iron tube, which has been let down behind the wall, discharges a strong and continuous jet at high tide. The well-known ebbing and flowing spring in the harbour is probably supplied from the same source.

I was for some time at a loss to account for the discharge of such a strong volume of water of fine quality from an apparently isolated and insignificant seam of gravel; but I am now of opinion that the water is derived from the chalk, either by the inland continuation and unconformable overlap of the gravel, for which the cliffs north of the town yield confirmatory evidence, or by the direct upward rise of the water through some gap or pervious place in the basement clay.

Water is shed copiously between tide marks along the range of chalk cliffs on both sides of Flambro' Head.

The Basement Clay (5). Of this boulder-clay I have given a full description in the *Geological Magazine* for December, 1881, p. 535, and need therefore give no further account of it here. I may mention, however, that I am at present trying to make a full collection of the older rocks which occur as boulders in such immense variety in this clay, with the hope that it may be possible to determine the source of many of them; and I shall be glad to send specimens for examination to anyone who thinks he can identify any local igneous rock known to him which may occur amongst them.

It will be observed that gravels containing a large proportion of chalk occur at three horizons in this section:—1st, above the sand and clay series (No. 2 of section):—2nd, above the Purple Clay (2*b*):—3rd, below the laminated clay. To these may be added the stratified boulder clay band *(3c)*, which if washed would yield a similar gravel.

I think this a point worth attention, as these gravels indicate the constant recurrence of an exposed chalk surface in the neighbourhood during the deposition of the boulder-clays;—a condition to be borne in mind when considering the origin of the clays. The chalk wold extends in a curved sweep about a mile to the north and west of the sections. On the promontory of Flambro' Head there are some gravels containing much chalk and others with none, and much might be learnt from a study of their mutual relations.

I regard the whole of the beds above the Purple Clay as of fresh-water origin, but shall be better able to submit my reasons after I have described the drainage sections.

I suggested last year that the intrusions and contortions between the Purple Boulder clay and gravel might result from the movement of ice in fresh-water. I have been confirmed in this view by finding similar disturbances amongst undoubtedly fresh-water beds in some sections shown in the banks of Watermill Beck, a small stream which empties itself across the beach about three miles to the south of Bridlington Quay. The great thickness of undisturbed clay and sand overlying the seat of disturbances in Figs. 1 and 2, shows conclusively that it is not a recent surface movement that has affected the beds. At the same time I may note that after much rain, water is shed pretty freely from the gravel above the boulder-clay, and also that the lower layers of the overlying warp are sometimes slightly drawn downwards into the crushed gravels.

The stratified band in the Purple Clay is another point which must not be forgotten by the glacial theorist. At first glance the stratification might be supposed to occur at random throughout the mass of the clay, owing to the constant change in the height and position of the band in a cliff-face always in some degree masked by landslips (which come and go over every point of the section at a surprising rate), but when once noticed, there is no difficulty in tracing it as long as the boulder-clay is visible.

The material of which it is composed differs so slightly from the clay above and below, that it has almost certainly been derived from the same source; yet there can be no doubt that this material has been sorted and deposited in water, for sometimes streaks of sand make their appearance along every bedding plane. It cannot therefore be directly the product of land ice; neither is its position, nor composition, such as I should expect from a subglacial river; nor from icebergs. It looks to me as if deposited in open water, of no great depth, with no ice excepting light floes.

The question arises with regard to the hummocky nature of the clay on which the stratified band rests, whether this is due to erosion, or disturbance, or to unequal deposition? Appearances generally favour the latter, though there are signs of erosion also.

I expect eventually to show that the band is on the same horizon as the the thick sands and gravels which separate the Purple Clay on the north side of the town, and I also believe that its southward continuation may be found in a similar band which may be traced almost continuously throughout the Holderness sections; though before I can speak of this with certainty, it will be necessary to see that there is not more than one horizon for stratification in the Purple Clay.

If finally proved to have so wide an extension, the stratified band will become of value as a dividing line in the clays, though there seems to be a growing tendency amongst glacialists since the breakdown of the evidence for a series of recurrent interglacial periods to avoid new lines, just as naturalists now avoid new species, and to 'lump' the deposits as much as possible. Yet I think that apart altogether from the theoretical aspect, lines such as these, in a confused and refractory mass like our boulder-clays, all deserve careful study, even though they be of no more intrinsic value than the bedding planes in a mass of limestone. To me, it does not seem necessary to 'lump' the whole of the sections because some present intricacies and difficulties; and although the local variations which exist in the sections obscure and confuse them, and render a very close and careful study indispensable in many cases,—the oftener I examine them the more satisfied am I that wide-reaching divisions other than those already made, exist both north and south of Flambro'.

GLACIAL SECTIONS NEAR BRIDLINGTON. PART II.

Sept. – Oct. 1882.

Length of Section 740 yards
Height from 25 to 45 feet

Fig. 1. Cliff Section south of Bridlington Quay Harbour

Scale 60 feet to an inch.

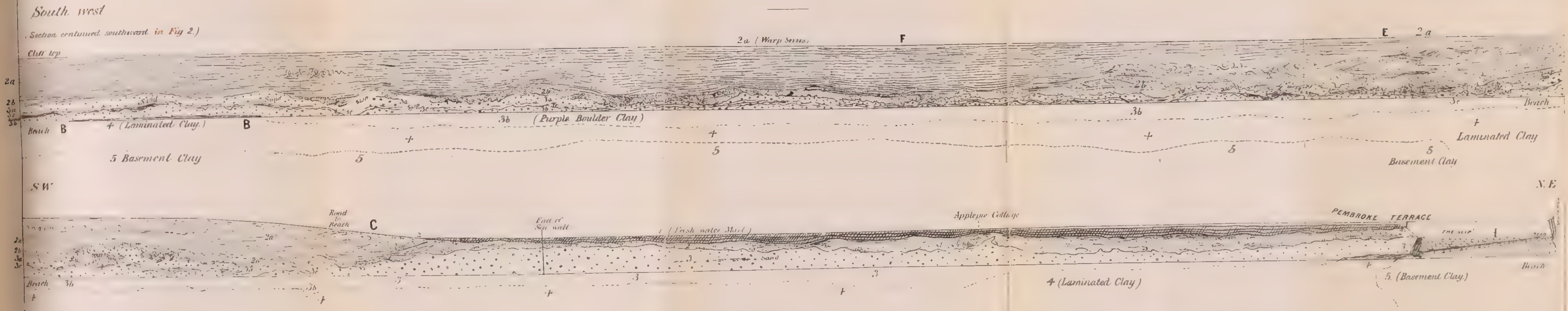
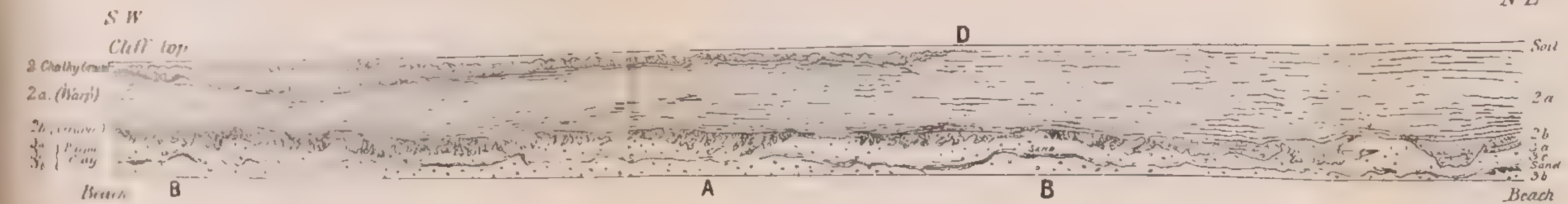


Fig. 2. Southward continuation of Fig 1. Same Scale.

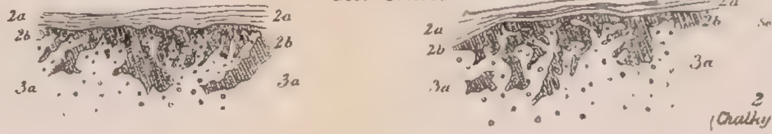
Length 170 yds
Height from 40 to 45 feet



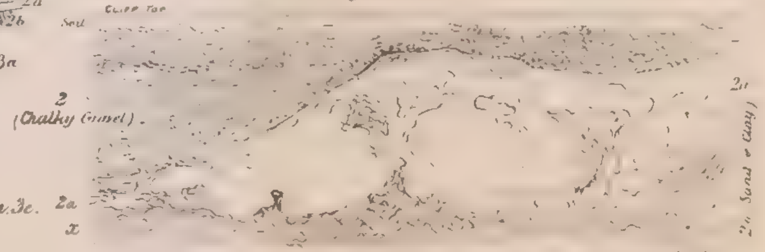
Enlarged Sections

Scale 10 feet to an inch in 1 & 2 – 6 feet to an inch in 3.

1 & 2. Sections near A in Fig 2., showing intrusion of Purple Boulder Clay into Gravel.



3. Section at Cliff top 500 yds. S.W of Fig 2 showing disturbance in bedding of Sand supposed to be concretionary



The unshaded portions of the sections are soft yellow sand; the lines indicate thin lines of Sandy Clay which stand out through weathering.
Along the line c. x the sandy ... drawn upward as it nears the centre of disturbance.

Explanation.

Top soil
1. Fresh water Marl
2 Chalky Gravel
2a Sand & Clay 'Warp' Series

3, 3a, 3b. Purple Boulder Clay, containing a stratified portion 3c.
4 Laminated Clay
5. Basement Boulder Clay.
The capitals indicate points referred to in the text

NOTES ON THE OCCURRENCE OF FOSSIL FISH REMAINS IN THE CARBONIFEROUS LIMESTONE SERIES OF YORKSHIRE.

BY JAMES W. DAVIS, F.G.S.

THE fish remains of the Mountain Limestone of Yorkshire are not numerous, neither are they found in a great number of localities. If the great area of the western and northern portions of the county be taken into consideration, which are more or less occupied by the Mountain Limestone, extending from Clitheroe and Slaidburn, Thornton, Skipton, to Greenhow Hill in the south, to the limits of the county westwards and northwards, and that in all these localities, and very many others, the rock is exposed and excavated for commercial and agricultural purposes, in quarries of enormous extent, there can remain but one conclusion, that whilst these rocks are replete with fossil mollusca, corals and encrinites there appears to have been a most remarkable absence of fishes in the seas of that period. The non-discovery may be attributed to a want of interest in this branch of palæontology, on the part of collectors, who may perhaps have been more deeply interested in the collection of the beautiful and perfectly preserved specimens of fossil brachiopods, corals and others which abound in many localities, largely quarried, whilst the less known and infinitely rarer remains of fishes have been neglected. Notwithstanding this disadvantage there seems to be little doubt that the absolute sterility of most localities must be attributed to the absence of fossil remains rather that than the need of collectors, and we are driven to the conclusion that, only in few localities and on special horizons have fishes been preserved in a fossil state. The reason for this peculiar arrangement opens a wide field for most interestting speculation. It would appear improbable that during the deposition of the strata containing fish-remains there was an abundant ichthyic fauna in the carboniferous seas, extending only over a comparitively limited area, and existing only for a sufficient period to accumulate, in most cases, a very thin stratum of limestone in which the fossils are preserved, and that during the longer intervals when the intervening thickness of limestone was deposited, there was an almost total absence of fishes in the sea. It has already been observed that the limestone is generally a homogeneous substance of a more or less crystalline structure, but the exploration of the present beds of some of the deep seas where chalk or limestone is in process of deposition has proved that side by side with the foraminifera which secrete calcareous substances, there are others which have a more or less siliceous skeleton and that the latter constitutes a portion of the substance forming the sea bottom. One of the peculiarities in connection with the great aggregation of fish-remains in the Red Beds of Wensleydale is, that the beds are extremely cherty, masses of nodular chert extend in horizontal layers in close proximity with the fish-beds. The method by which the nodules and beds of chert have been separated is not understood; it is possible that the presence of submarine thermal springs, due to volcanic action, may have something to do with the aggregation of the silica to form the cherty or flinty masses. If such be the case, it might be equally probable that the ebullition of water, charged with perhaps poisonous ingredients, would result in the destruction of large numbers of fishes, and in this way the fish-beds may have originated. Except on some hypothesis such as this, it is difficult to conceive a good reason for the occurrence of immense numbers of fish-remains on definite horizons of small thickness, and their almost total absence throughout great thicknesses of intermediate limestone.

Notwithstanding the extreme localization of the beds containing fish-remains there is no reason to complain of the numbers of either specimens or species in localities where they do occur and have been carefully collected, but as will be observed further on, the characteristics of the Yorkshire Limestone fishes are peculiar. In many respects they are distinguished from those, either of the limestone of other localities of the British Islands, or of the coal measures which succeeded them.

Amongst the more frequent examples of ichthyodorulites found in the Mountain Limestone of Bristol, in which locality numerous specimens have been discovered, are the spines and teeth of large predacious fishes allied to the sharks now living. Some of the fish-spines are of immense size. An example in the collection of Earl Ducie at Tortworth Court, which is imperfect at the base, was probably, three feet in length. The fish to which it belonged, judging by comparison with living forms, must have been nearly forty feet in length. Many other genera and species of fishes which were possessed of large fin-defences occur in the limestone on the banks of the Avon.

The limestone at Armagh, in Ireland, contains a large number of teeth, which from their peculiar angular margins and flat surfaces, have evidently occupied the mouth of the fish with a flat pavement-like arrangement. This form of dentition is admirably adapted for preying on animals enclosed by hard shells like the mollusca. Perhaps the most characteristic teeth of the Yorkshire Limestones are those of Petalorhynchus and Pristodus, the dentition of the latter resembles that of the peculiar fish Diodon, now living in the seas under the warm rays of the tropical sun. In Diodon, each jaw is occupied by a single tooth which extends over the palate as well as envelopes the outer margins of the jaws.

Besides the fishes mentioned, which appear to be localized and peculiar to certain districts, there are many others which are common to all of them. Groups represented by the twisted teeth of Cochliodus, the pavement-like teeth of Psammodus, and the sharp-pointed, shark-like teeth of Cladodus, are found in greater or less abundance in all the localities where fossil fishes have been discovered.

The larger proportion of the fish-remains of the Carboniferous Limestone appear to be restricted to the formation; they are not found in the earlier strata of the Old Red Sandstone or the still older Silurians. The fishes found in the Old Red are comprised in the externally armour-plated fishes of which Coccosteus may be taken as the type, and the thick, enamel-scaled fishes represented by Cheirolepis, Acanthodes and Osteolepis, all of which are ganoids. In the Mountain Limestone, Ganoid fishes are almost entirely absent, being represented only by a few plates of Cœlacanthus from Armagh; unless it shall be found that the various-shaped pustulate plates of Oracanthus represent the external armour of a fish allied to Coccosteus.

The great Elasmobranch fishes, armed with dorsal fin-spines of great power, for either offence or defence, became of great importance during the limestone era, they are represented in earlier formations only by the small spines of Onchus in the Silurians. In later formations some of the Limestone Elasmobranchs are represented by descendants in the genus Ctenacanthus; others may also possess characters more or less common to the genera of both formations. In the shales of the coal measures, ganoid fishes of very large size such as Rhizodus and Megalichthys become of frequent occurrence, the rare Cœlacanthus of the limestone, in the Cannel coal becomes an extremely abundant genus, and several placoid fishes possessing characteristics quite different from those of the Mountain Limestone becomes tolerably abundant. The Acanthodians, which were common in the Old Red Sandstone strata, but absent from the limestone, again put in an appearance in the coal measures. The great majority of the limestone fishes, however, are not found in the coal measures, the great group of Copodonts and Psammodonts, the Cochliodonts and the last remnant of the Coccostean group, if Oracanthus be such, have all disappeared prior to the deposition of the coal measures.

It must not of necessity be supposed that the changes indicated above were of univeral significance, it is far more probable that they were due to circumstances more or less localized in extent. The Carboniferous Limestone is a deep water formation, and the fish-remains contained in its strata were doubtless those of the fishes which inhabited those deep waters, but the Old Red Sandstone formations were accumulated in much shallower water, probably in many cases formed the shore during the deposition of the Limestone in the deep waters beyond, the fishes found fossil in those beds, may naturally be expected to differ in character from those of the deep water. The Coal measures again are the result of deposits of sand and mud brought from the land by streams either to an estuary of the sea or inland lakes, in either case, the piscine fauna may be expected to exhibit peculiarities totally different to those of the fauna of the Limestone.

It is proposed after giving the list of fishes found in the Yorkshire Limestone series which immediately follows, to consider the relationship they appear to possess with other fossil forms, and their zoological position with regard to allied fishes now existing, and to draw such inferences therefrom as may seem desirable.

Cladacanthus paradoxus, Agass.	Leyburn.	
Physonemus arcuatus, Agass.	,,	
Cladodus mirabilis, Agass.	,,	
,, striatus, Agass.	,,	Settle
,, basalis, Agass.	,,	
,, Hornei, Davis.	,,	
,, mucronatus, Davis.	,,	
Pristicladodus dentatus, McCoy.	,,	
,, Goughi, McCoy.	Kettlewell.	
Glyphanodus tenuis, Davis.	Leyburn.	
Orodus ramosus, Agass	,,	
,, Reedi, Davis.	Richmond.	
Lophodus reticulatus, Davis	Wensleydale.	
Diclitodus scitulus, Davis.	,,	
Cochliodus contortus, Agass.	Leyburn,	
Deltodus aliformis, Agass.	,,	
Deltoptychius acutus, Agass.	,,	
Psephodus magnus, Agass.	Settle.	
Pœcilodus Jonesii, Agass.	Leyburn.	
,, sp., nov.	,,	
Pleurodus Woodi, Davis.	Leyburn,	Richmond.
Psammodus rugosus, Agass.	,,	Settle.

Dimyleus Woodi, Agass.	Leyburn.	
Petalodus accuminatus, Agass.	„	Settle, Richmond.
Polyrhizodus, sp.?	„	
Petalopsodus tripartitis, Davis.	„	
Ctenopetalus serratus, Agass.	„	Richmond.
Petalorhynchus psittacinus, Agass.	„	
Pristodus falcatus, Agass.	„	
Megalichthys, sp.?	„	

The whole of the fish remains enumerated above are comprised in the sub-class, *Palæichthytes* as defined by Dr. Gunther. The sub-class includes two orders, the Chondropterygii and the Ganoidei. The latter is equivalent to Prof. Huxley's Ganoidei and Dipnoi, whilst the former comprises the Elasmobranchii of Prof. Huxley's classification and includes the sharks, rays, and chimeras. The order Chondropterygii is divided into two sub-orders: Plagiostomata, comprising the sharks and rays, and the Holocephala, the chimeras. The Elasmobranch fishes of the Mountain Limestone are all included in the Sub-order Plagiostomata. The remains of these fishes which have been preserved are always in a disintegrated condition and consist of detached teeth or spines. A slight consideration of the anatomy of an existing shark will at once explain the reasons why this is so. The framework of a shark is cartilaginous; the mandibles, skull, supports for the fins, &c. are each unossified, though well developed; and the vertebræ are also in many cases cartilaginous though various modifications occur. In some there is a slight ring of bone imbedded in the cartilage, in others the whole of the vertebra is ossified. The vertebræ of the plagiostomous fishes whose remains are found in the Carboniferous Limestone appear to have been entirely cartilaginous, for hitherto no trace has been found of their preservation. The only parts of the fish which have been preserved are the teeth, the spines which occupied positions in front of the dorsal or pectoral fins, and occasionally patches of the dermal covering like shagreen. The organs on which, since the researches of Johannes Müller, modern classification has been based—the heart, the spiral intestine and the optic nerves, have entirely disappeared, and it is only by comparison of the parts preserved fossil with similar ones in existing fishes that we are enabled to affirm that as in the recent fish, the teeth, &c. bear functional relationship with the soft parts of the fish, so in the fossil state similar teeth must have borne a corresponding relationship with the parts of the fish which have disappeared. That the remains which are preserved should be mixed up in almost inextricable confusion is not remarkable when it is remembered that after the cartilaginous portions of the fish, which connect its several hard parts, have become decayed, the latter, each separated from the other, are liable to be washed hither and thither by every tide or current, and to become widely separated and intermixed with remains of other fishes so that it is an occurrence of extreme varity to find even the teeth of a fish in so happy juxtaposition that they can be identified as pertaining to the same individual.

In attempting to trace the affinities and relationships of fossil fishes to recent forms the divergence between them is in some cases apparently slight, whilst in others, characters are developed which, unless they be regarded as connecting links between an older fauna and the present one, are inexplicable. So far as there is any evidence at present known, the Lower Silurian and all preceeding formations are devoid of fish remains; from which it may be inferred, that the advent of fishes took place during the deposition of the Upper Silurian Strata. During the succeeding Devonian and Old Red Sandstone age, immense numbers of fishes swam in the seas. In size they were little inferior and in structure they were scarcely less highly organized than the fishes inhabiting the waters at the present day. Notwithstanding this, they present many peculiarities which have long since disappeared and been replaced in following ages by others, again to flourish for a while and in their turn disappear. The fishes of the earlier formation whilst perfectly organized present a much simpler fauna than in succeeding ones, and whilst the number of individuals may have been as large as during any succeeding age, the diversity of form, which for convenience of reference we designate by the terms genera and species, has greatly increased; and at the present time the repeated divergence of the original forms through succeeding ages has produced an almost endless variety, infinitely greater than at any previous portion of the history of the world. It is more than probable that this great variety of forms has been produced by repeated slight differentiations from the parent stock, which, rendering the offspring better capable of adaptation to an altered environment, or presenting some feature more readily transmitted has gradually modified the species until all trace of relationship with its first parents is lost. It is for this reason, amongst others, that the study of fossil forms is essential to a thorough knowledge of existing fishes; the characters found in different families of the latter, now quite distinct, were originally combined or blended in the earlier fishes, so that the fossil fishes form links in an almost endless chain, which renders their study of intense interest to the modern biologist. The imperfections in this developmental chain are great; but every new addition to the knowledge of fossil ichthyology, derived from new or well preserved specimens, serves to throw additional light on the subject and to render a complete elucidation of the relationships of living species more possible.

Until a comparatively modern epoch the group of fishes with a bony skeleton, the Teleostei, which form by far the largest portion of existing fishes, is not represented in a fossil state, their first appearance being during the deposition of the chalk. The Plagiostomata or sharks have been represented from the earliest times to the present. Traces of this group are first observed in the Upper Silurian rocks of Ludlow, and they have continued to exist in greater or less profusion through every succeeding geological epoch. In the Carboniferous series of rocks the number of species already discovered is very large, and comprises a considerable variety of plagiostomous fishes which have since disappeared. Prof. Agassiz considered that a large proportion of the Carboniferous fishes bore a greater resemblance to the Cestracion,or Port Jackson Shark, than to any other existing genus ; the latter is represented by one or two existing species only, and appears from its comparatively small numbers and localized extent to be almost on the point of extinction. An important characteristic of the sharks of the older geological ages lies in their possessing, to a much larger extent than at present, large fin-spines, in many instances highly ornamented.

The Ganoidei, which comprises an enormous assemblage and great variety of fishes in the ancient geological periods, is now reduced to a comparatively small number of species inhabiting the rivers of America and Africa, and the sturgeons which are marine. The typical ganoid, represented by the Garpike (Lepidosteus) of the American rivers, or the fossil Megalichthys, is covered with a coat of rhomboidal, thick, bony scales, with an enamelled surface. There are however, many exceptions to this character, and the living Amia of the American lakes, covered with thin imbricated scales, is devoid of enamel, they are of small size, very similar to some of the bony fishes.

The groups of fossil fishes found in the Yorkshire Limestone Series included in the sub-order *Plagiostomata* are the following.

Hybodontidæ,	represented by	Cladodus, Pristicladodus and Glyphanodus.
Orodontidæ	,, ,,	Orodus, Lophodus and Diclitodus.
Cochliodontidæ	,, ,,	Cochliodus, Deltodus, Psephodus, Deltoptychius and Pœcilodus, (perhaps Pleurodus.)
Petalodontidæ	,, ,,	Petalodus, Polyrhizodus, Petalopsodus, Ctenopetalus, and Petalorhynchus.
Psammodontidæ	,, ,,	Psammodus.
Copodontidæ	,, ,,	Dimyleus.
Ichthyodorulites	,, ,,	Cladacanthus and Physonemus.

Besides these, the teeth of the genus Pristodus, which cannot be included with any of the above groups, but whose affinities seem to lie in the direction of the Plagistomata, is very abundant in the upper bed of the series and is peculiar to this district.

In other localities the group *Hybodontidæ* is represented by several genera of spines which bear a greater or less resemblance to the Hybodus of the Lias. Amongst the most formidable of these are the spines of Ctenacanthus and associated with them the teeth called Cladodus. It has been thought probable, from the spines of Ctenacanthus and the teeth of Cladodus occuring together with considerable frequency, that they may have been co-existent in the same fishes. It is well known that the spines of Hybodus of the Lias were associated with teeth to which Cladodus bear some resemblance. The latter differ from Hybodus in the cusps produced from the surface of the crown being longer and sharply pointed; in other respects they are similar. A peculiar circumstance in connection with this group in the Yorkshire Limestone is that, whilst the teeth of Cladodus are represented by five or six species, some of which, like C. straitus, are very common; there has hitherto been no specimens of Ctenacanthus discovered. The teeth occur in the thick-bedded limestone of Settle and Giggleswick, examples from the quarries in the neighbourhood may be seen in the Museum of the Grammar School of the latter place; they also frequently occur in some of the thin limestones in Wensleydale, comprised in the Yoredale series of Prof. Phillips, and in the limestone quarries in the neighbourhood of Richmond, but in none of these localities have the spines of Ctenacanthus been discovered. Considering the large numbers of teeth of Cladodus which have been found, and the absence, hitherto, of any evidence of spines, even approaching in character to Ctenacanthus, negative evidence of considerable weight is afforded that the two genera were not so closely related as has been suggested, or at any rate, that the teeth of Cladodus may have belonged to a predaceous fish unprotected by fin-rays, in the Carboniferous area in this district.

The genius Pristicladodus is in many respects similar to

Cladodus, it is a thicker and stronger tooth with only one lateral cusp on each side the large central one. The name was given originally by Prof. M. Coy to teeth from the Limestone of Derbyshire. Glyphanodus is a very peculiar species, the teeth are excessively thin and compressed, the crown consisting of a single median cone with a chisel-like edge, sharp and smooth. The base descends co-extensively with the crown and resembles that of the Petalodonts more than Cladodus which usually extends in a more or less horizontal direction backwards; the crown of the tooth is however, much more closely related to Cladodus than the Petalodonts, possessing characters which would associate it with both genera it may perhaps be looked upon as a connecting link between the two. It has been found only in Yorkshire.

The teeth comprised in the group *Orodontidæ* have a very wide distribution both in the British Islands, on the continent of Europe, and in America. Those found in Yorkshire comprising two species of Orodus are small and comparatively rare; there is also one species of Lophodus and a new genus Diclitodus. The latter has only been found in Yorkshire, it differs from the genus Orodus in possessing two equal cones raised from the crown; in other respects it bears a considerable likeness to the Orodonts and has been placed provisionally amongst them.

The Orodonts in the Limestones of Bristol and Armagh are very much larger in size than the Yorkshire ones but it is rarely that two or more teeth are found in juxtaposition though two or three instances have occurred in which three or four teeth have been connected together in such a manner as to leave no doubt that they still retained a natural position. Though examples are rare in this country of specimens which exhibit the arrangement of the teeth on the jaws, American palæontologists have discovered at Osage, County Kansas in America, an extremely well preserved series of teeth which illustrate the whole dental arrangement. The teeth are from the coal measures and are described in "Palœontology of Illinois" Vol. VI. p. 311, by

Messrs. St. John and Worthen. Though very closely related to Orodus the authors consider that minor differences are sufficiently distinctive to form the new genus Agassizodus for the accommodation of the specimens. About four hundred and fifty to five hundred teeth comprised the whole of the left ramus of the lower jaw and a portion of the right one. In their description of this remarkable specimen the authors state that "the articular extremities of the jaw are not preserved, though fragments of the substance of the cartilage are scattered through the rock mass upon which the teeth are imbedded. These cartilages were doubtless comparatively thin, the outer and inner folds giving way to the pressure which flattened the rami, as shewn in the present condition. The teeth are disposed in serial rows having a convoluted inrollment from the inner to the outer border, and gradually increasing in size from the posterior extremity to the row of large median teeth, anterior to which the rows as regularly diminish in size towards the symphysis," the posterior portion of the jaw has six to nine rows of teeth similar in form to, but of smaller size than the teeth of the median portion. The middle portion of the ramus is occupied by a row of proportionately very large teeth which differ from the posterior teeth in having the crown produced into a strong, obtusely conical excentric prominence which culminates at a point more or less posterior of the middle of the tooth, whilst the posterior teeth are devoid of any defined median keel. The anterior portions of the teeth are very similar to those situated posteriorly of the median row. There are eight to nine rows, and contrary to the posterior ones they gradually diminish in size anteriorly as they approach the symphysis of the jaw. In the extreme anterior rows the teeth assume considerable diversity of form, and there are a number of minute, nearly circular teeth which exhibit in the form of the crown, and its sculpturing a strong likeness to Petrodus. "Generally considered, the teeth present the closest affinities with *Orodus* Ag., a group prevalent in the Lower Carboniferous formation." But the present group of teeth is distinguished by the prevailing prominence of the buttressed condition of the anterior coronal borders, and the relative uniformity or evenness of the posterior face, besides the relatively fewer rows of acuminate teeth, as inferred from this feature being so prevalent in all collections of Orodi, while the linear forms are least commonly met with. The authors also state that in addition to the teeth and pieces of cartilaginous matter which appear to have formed the supports of the jaws, there were a number of exceedingly small bodies "irregularly circular in outline, with a depressed convex coronal portion, which rises into an eccentric acumination or transverse ridge along one side, and delicately sculptured with irregular carina radiating from the apex towards the marginal borders." Below they are concave. No two specimens appear to be exactly alike, though they have a general resemblance, especially in the dark horny luster of the enameled crown, by which they are readily distinguished from the teeth with which they are associated. It seems not improbable that these minute bodies constituted part of the dermal covering or shagreen of the fish.

The description of the fossil Agassizodus from the Kansas coal measures bears a close resemblance to the description given by Prof. Owen of the dentition of the modern Cestracion, and as the subject forms one of the few rare instances in which one of the earlier plagiostomous fossil fishes can be reliably compared with an existing form, I venture to give Prof. Owen's description as follows, "The teeth at the anterior part of the jaws are the smallest; they present a transverse, sub-compressed, conical figure, with the apex produced into a sharp point; these points are worn away from the used teeth at the anterior and outer parts of the jaw, but are strongly marked in those which still lie below the margin. There are six subvertical rows of these small cuspidate teeth on each side of the jaw, together with a median row close to the symphyseal line; and from twelve to fourteen teeth to a row. Behind the cuspidate teeth, the five consecutive rows of teeth progressively increase in all their dimensions, but principally in their antero-posterior extent; the sharp point is converted into a longitudinal ridge, traversing a convex crushing surface, and the ridge itself disappears in the largest teeth. As the teeth increase in size, they diminish in number in each row; the series of the largest teeth includes from six to seven in the upper and from seven to eight in the lower jaw Behind this row, the teeth, although preserving their form as crushing instruments, progressively diminish in size; while at the same time the number comprised in each row decreases. From the oblique and apparently spiral disposition of the rows of teeth, their symmetrical arrangement on the opposite sides of the jaw, and their graduated diversity of form, they constitute the most elegant tesselated covering of the jaws which is to be met with in the whole class of fishes" (Odontography, page 51). A comparison of the two forms shews how small is the difference between them, both in the characters of the teeth and in the form of arrangement. The arrangement of the fossil is almost exactly similar to the appearance which would be presented by the teeth of Cestracion if they were spread out and compressed. The most striking difference between them lies in the more obtuse arrangement of the anterior portion of the jaw of Agassizodus. It may be naturally inferred that Agassizodus and the Orodonts generally, like the living Cestracion, fed on Molluscs and other animals which were protected by, or encased in hard shelly coverings, the arrangement of the flat crushing teeth admirably adapting them to break or crush the hard substances in order to extract the animal. The size of the fossil Orodonts may be inferred from a comparison with the existing species. The Cestracion found off the the shores of Australia is two to three feet in length and the jaws from three to five inches, the jaws of Orodus ramosus were probably three feet in length, and this would give the length of the fish at about thirty feet, a truly formidable creature.

The modern Cestracian is possessed of two defensive spines, one before each dorsal fin, but there is no evidence to shew whether the fossil Orodonts had such spines; the discoveries of further examples may serve at some future time to shew whether they had or not: so far as the evidence of the specimens found in Yorkshire goes, it would seem to indicate that they were not so defended.

Several species of the genus Lophodus have been found in the upper beds of limestone in Wensleydale. The genus was originated by M. Rowanowsky, in 1864 ("Bull. de la Soc. Imperial des Naturalists de Moscow," p. 160), and embraces the teeth of fishes which are closely allied with Orodus but present several features which had hitherto been considered to be characteristic of Helodus. Lophodus comprises teeth in which the crown of the tooth is more or less conical in outline with a corresponding concavity of the base, whilst in the teeth of Helodus there is no such concavity, and the crown, somewhat expanded laterally over the base, rises up from all sides to the apex. The base of the crown in Lophodus is contracted on each side and curved inwards to the root.

The Cochliodontidæ are well represented in the Yorkshire limestones, so far as number of genera goes, but the number of specimens found have not been very great. The genera comprise species in Cochliodus, Deltodus, Deltoptychius, Psephodus and Pœcilodus; they differ very considerably from each in many minor peculiarities, but they agree in others of greater importance. The distinguishing characteristic of the group is, that the teeth "grow or increase in size, not as in most fishes by the old and worn teeth being replaced from behind or below, but by continuous or repeated additions to the inner or posterior margin of the surface of the tooth, so that the same tooth is always increasing in size with the growth of the fish, and assumes an inrolled or convoluted form. An analogue of this pecular growth is seen in that of the testaceous covering of the mollusca, which though it assumes a wonderful variety of forms, increases in size by the addition of repeated layers to the open margin of the shell."* The genera Cochliodus, Deltodus and Deltoptychius exhibit a distinctly inrolled appearance in a transverse section, whilst Psephodus and Pœcilodus are flatter and increase in size by the radial expansion of the triturating surface. Hitherto, the complete dentition of any member of the group has not been found, but specimens of several of the genera shew that there were three teeth on each jaw; those in front which approached and joined at the symphysis of the jaw were the smallest, and the second and third pairs increased in size backwards. Those situated most posteriorly are expanded so as to form a wide, more or less convex surface, admirably adapted for crushing and triturating vegetable substances for food, which in all probability formed the principal part of their sustenance. The teeth were attached and partially imbedded in a strong cartilaginous jaw, which possibly extend inwards as to form a palate to which other teeth may have been attached. That teeth similar to those hitherto named Helodus may have occupied the central portion of the palate, is rendered probable by the discovery in some of the American strata of specimens of Cochliodus and Helodus in close apparent relationship, though the specimens found in this country have not indicated such a combination.

As already stated, the teeth of Cochliodus have a distinctly inrolled or helicine configuration whilst those of Psephodus are much flatter and very slightly curved. The latter vary greatly in size, as well as to a smaller extent, in form. The teeth of Cochliodus have been found not only connected together but the teeth of the two rami of the jaws united by their cartilaginous supports; the teeth of the Psephodus, however, have not been discovered so united, but their arrangement has been proved to be similar to those of Cochliodus by the peculiarly concave under surface. If one of the largest teeth be examined it will be found that the widest posterior edge is rounded, whilst the opposite edge of the tooth is more or less straight and rectangular, corresponding with this arrangement of the crown, the under surface, which was attached to the jaw, is seen to be concave, the concavity forming a channel or grove, widest at the rounded posterior extremity of the tooth, and diminishing in diameter as it approaches the straight edge. Median teeth may be selected which exhibit a similiar decrease from the back towards the front of the tooth in the channelled inferior surface whilst both margins are more or less straight. The widest end is equal in diameter to the narrowest of the previous tooth, and it diminishes forwards and is connected with a third and still smaller tooth which occupies the space between the median and the sympysis of the two rami composing the jaw. The inferior channel on the third tooth diminishes still more in diameter, and near the symphysis is almost attenuated to a point. In each tooth there is the characteristic convolution. One or two specimens have been discovered with long, narrow teeth attached in front of the teeth on each side the symphysis more or less resembling those called Helodus; it appears probable that these were attached in front of the anterior pair of teeth, which are small and narrow, in order to seize and secure their prey with greater facility; it is also possible that there may have been other smaller teeth distributed over the median portion of the palate.

---

* Proc. Roy. Soc. Dublin, New Ser. Vol. I., p. 415.

The teeth of the other genera, Deltodus, Deltoptychius and Pœcilodus appear to have been arranged with modifications to suit their several peculiarities in form, in approximately close relationship with those already described. For the most part they had three teeth increasing in size backwards, as indicated by the channelled surface attached to the cartilaginous jaw, but it is probable that the teeth of the upper jaw of Deltodus and Deltoptychius existed singly, in this respect approaching the arrangement in the jaws of Ceratodus. The teeth in both jaws of Pœcilodus may have been single.

The Cochliodonts have been regarded by Prof. Owen and others as based on the type of the modern Cestracion or Port Jackson shark, differing from it, however, in possessing few and large teeth in place of a greater number of small ones. Prof Agassiz in the third volume of his Poisson's Fossiles, p. 113, regards Cochliodus as nearly related to Ceratodus; and considers that the relationship proves that Ceratodus is a plagiostomous shark, both being closely related to the genus Cestracion. Since Prof. Agassiz penned his description, an existing representative of the Ceratodus has been discovered in the mud-fish of Australia, whose dentition is in every respect similar to the fossils described by Prof. Agassiz. The relationship of the living fish is proved to be with the Ganoids, and it is not improbable that the Cochliodonts of the Limestone Formations may eventually be found to be much more closely related to the Ceratodus than to the Cestracionts. The dentition of Orodus and the American genus Agassizodus have been shewn to be very closely related to the living Cestracion; they were co-existent with the Cochliodonts, and it is extremely improbable that they were closely related; in arrangement and adaptation for feeding they are quite different from each other, the Cochliodonts for vegetable feeding and the Cestracionts to prey on Mollusca, &c.

The teeth of the Pleurodus Ag. occur in the Limestone in Wensleydale with considerable frequence. They are small, and in all probability are a different species to those found in the coal measures. Though this genus possessed a cartilaginous skeleton, its remains have been discovered in the shales of the coal measures at Newsham in Northumberland, and in those of the West Riding of Yorkshire, so well preserved that the form of the fish could be ascertained. It was four inches to a foot in length, having a deeply rounded and flat body with a spine in front of the dorsal fin immediately behind the occiput about one third the length of the body, one half the length of the spine was probably buried in the integuments of the fish. In the Newsham specimen the position of the spine and the form of the fish are clearly indicated by the expanse of chagrin or dermal tubercles which has remained quietly in position; at the anterior extremity ten or twelve teeth indicate the position of the head. Supposing the number of teeth to have been twelve, there would be three to each ramus of the jaw, which is the same number as in the Cochliodonts. The teeth of Pleurodus are not unlike those of Pœcilodus in form, and surface configuration, and it is within the range of possibility that there may be some relationship between the members of the Cochliodont group and Pleurodus, though it may be advisable to withhold a detailed expression of opinion until more extended observations shall have been made.

The representative of the Psammodontidæ occurring in Yorkshire are not numerous, and are small compared with those of Bristol and Armagh. They possess the usual characteristics of the group, and formed a flat pavement-like arrangement in the mouth admirably adapted for crushing the hard coatings of testaceous animals. Prof. de Koninck in his description of the Fossil Fauna of Carboniferous Limestone of Belgium, has suggested that the teeth were arranged so as to cover the whole of the palatal surface of the mouth; the square massive teeth being joined at their edges, and having on each side and in front smaller teeth, in some cases somewhat triangular in outline, to fill up the rounded conformation of the jaws.

Associated with the Psammodonts are smaller teeth, similar to them in being flat on the surface, but dissimilar in other respects. They were named by Prof. Agassiz, but not described, as Dimyleus Woodi, from specimens contributed by the late Mr. Wood of Richmond in Yorkshire, to the Enniskillen collection. At Armagh many other genera of fish-teeth have been found, which closely approximate with those of Dimyleus found in Wensleydale. A careful study of the whole group shows that they are distinct from the Psammodont family. They have therefore been grouped together as a distinct family, Copodus being regarded as the typical genus, they are termed the Copodontidæ.

Perhaps the most remarkable group of fish-remains found in the Yorkshire Limestone is comprised in the Petalodontidæ. The group was instituted by Messrs. Newberry and Worthen (Geology and Palæontology of Illinois, vol. ii, p. 31), and embraces several genera of fishes known only by their teeth, and so far as at present discovered, confined to the Carboniferous series of rocks. The genera which occur in this county are Petalodus, Agass; Petalopsodus, Davis; Polyrhizodus, McCoy; Ctenopetalus, Agass; and Petalorhynchus, Agass.

The genus Petalodus is represented by the well-known species Hastingsiæ and acuminatus. The latter is fairly abundant and frequently of large size, but otherwise the genus does not offer any features of peculiar interest. Polyrhizodus is represented by only one small and very rare species. This genus frequently occurs in the Limestone of Ireland, and appears to be of sufficiently diversified and well defined character to necessitate the formation of at least six species. The teeth are in many respects similar to those of Petalodus. The strong, well-developed crown with a sharp cutting-edge is equally characteristic of the two genera; the principal difference consists in the formation of the basal portion which was inserted in the jaw of the fish; in Petalodus the base is composed of a single massive root, whilst in Polyrhizodus, as implied in the name, the root is divided into a number of radicals or rootlets, varying in number from four or five, to sixteen or twenty. This character of the root of Polyrhizodus is very peculiar, and does not occur in any other group of fishes, either recent or fossil. The teeth of most of the Plagiostomous fishes are simply attached to the jaw by their under surface in a somewhat loose manner, and as might be supposed, not being firmly implanted in the jaw, but only *on* it, they are easily displaced. To compensate for this liability to loss, the fishes are provided with several rows or series of teeth, which until required, are arranged on the inner side of the jaw, their sharp edges pointing towards the palate. On the displacement or breakage of the teeth in active use, they are replaced by others from the reserve; this character obtains in all the Squali or sharks properly so called. In other groups with a flat and crushing dental arrangement, the old teeth are replaced by new ones which grow underneath them, or like the Cochliodonts, the old portion becomes inrolled on the jaw and a new surface is produced by additions to its lateral edges as already explained. The Petalodonts were very differently attached to the jaw; a strong and deeply-imbedded attachment to the jaw gave them a solidity more analogous to some of the Teleosteans, as for example, Sargus, or the higher vertebrates, than to the sharks, and in this respect the genus Polyrhizodus is more distinguished than its fellows by having the roots divided, and by that means being still more firmly attached to the jaw.

The genera Ctenopetalus, Ag., and Petalopsodus, Davis, are distinguished, the first by its serrated or crenated cutting surface, and the latter by having the coronal edge divided into three distinct and almost equal parts, each rising to a finely pointed apex. The root is not divided. The remaining representative of the group, the Petalorhynchus, Agassiz, is much the most abundant and has been found in large numbers. It is also very fortunate that several specimens have been discovered which throw considerable light on the general dentition of the genus. It is now known that the teeth were arranged in a semicircle conforming to the shape of the jaw in which their long roots were deeply implanted. The root in the older teeth is frequently four times the depth of the height of the crown. The crown has the usual Petalodont character, except that its central portion is produced and pointed, and is slightly bent inwards so as to resemble the pointed beak of a parrot. One central tooth was implanted on the symphysis of the two rami of the jaw, and on each side there extended three others, making a total of seven to each jaw. Specimens have also been found shewing how the teeth are replaced by successive larger growths, as the mouths of the fishes has increased in size. From these it appears that originally there was a single row of small teeth extending along the surface of each jaw, that, as these become worn and the fish increased in size, they were replaced by a set of larger teeth from the inside of the mouth, somewhat similarly to the increase in the sharks, except that the earlier row of teeth instead of becoming detached, adhered to the second or new row, and becoming firmly cemented to them served to strengthen and support them. In this way successive additions were repeatedly made, each additional row by its increase in lateral extent as well as in length being proportionate to the increased growth of the jaw. Specimens have been found with five such rows, all firmly cemented and adhering to each other.

The peculiar constitution of the jaw and teeth of Petalorhynchus with the median teeth over the symphysis of the jaw is aberrant from the usual type of the Selachians, and it has to this extent some affinity with the Rays. Messrs. Hancock and Atthey have pointed out the relationship of Climaxodus, McCoy, and Janassa, Münster, in a paper in the "Natural History transactions of Northumberland and Durham, vol. iii., pt. II., p. 330." The arrangement of the teeth of those fishes is very similiar to that of Petalorhynchus, they extend, however considerably more in a horizontal direction, over the palate of the mouth, and in addition to the sharp cutting-edge of the extremity of the tooth, the crown was developed so as to form crushing or triturating surfaces. The authors after a minute description of the specimens arrive at the conclusion that Janassa, Münster, approaches somewhat in character to Myliobates of the newer formations, which have a broad tooth occupying the median portion of the mouth with three rows of smaller teeth on each side extending from the extremity of the jaws inwards over the palate. Should this relationship be established and confirmed by the discovery of intermediate species, an interesting evolutional series may be traced from the Petalodonts of the Lower Carboniferous Limestone, through Chinaxodus of the upper beds of that series, the Janassa of the Permians, to the Myliobates of the newer formations to the members of that genus which still exist in the seas of the present time.

Before leaving the consideration of the relations of the Petalodont family to other groups of fossil or living fishes, it may be worth while to note the somewhat peculiar resemblance possessed by some members of the genus *Sargus*, at present existing in the warmer sub-tropical seas. Taking as an example *Sargus Rondeletti*, Cuv. and Val., the teeth present an extremely interesting arrangement. Along the anterior extremity of each ramus of the jaw there are four teeth, deeply rooted or implanted in the strong bony framework of the jaw; the portion of the teeth forming the root, and extending some distance beyond the surface of the jaw, is broad antero-posteriorly and somewhat contracted laterally; nearer the apex, however, the tooth becomes laterally expanded, spreading out into a spatulate concavo-convex crown, terminating in a thin straight cutting edge, with highly polished enamel surface and very sharp. The largest teeth are on each side the symphysis of the two rami, and occupy the central portion of the jaw, those on each side decreasing in size backwards, the posterior teeth being less than half the length or breadth of those in front but still preserving the same characters. The resemblance to the Petalodonts is probably merely an accidental one. They differ in the arrangement of the median teeth which are separated by the simphysis of the jaw, and do not extend across it as the Petalodonts do. Sargus lives in the waters on the coast of Madagascar, and its spatulate teeth are admirably adapted for seizing molluscs like the limpet which adhere strongly to the rock or other substance on which they exist. The resemblance may at least indicate a parallel in the food of the two genera.

Pristodus falcatus, Agassiz, occurs frequently in the upper beds of the limestone series of Yorkshire. A single tooth appears to have enveloped the whole of the upper or lower jaw to which it was attached, and extended along the palate and floor of the mouth inwards, so that the two teeth fit each other. The external edge envelopes the jaws, that of the upper jaw being extended downwards so as to considerably overlap the lower one. The extended edge forms a cutting surface which is toothed like a saw with the largest denticles in front and gradually diminishing in size backwards. The tooth of the lower jaw is devoid of denticles; it is raised in the centre of the external edge in the form of a single point, which fits a corresponding hollow inside the margin of the upper tooth. The pair of teeth present a resemblance to the beaks of a parrot, in the manner in which they fit to each other.

Amongst the fishes of the primary or secondary rocks there is no other genus known which approaches in form and character to Pristodus. Amongst living fishes the Diodonts offer a somewhat close resemblance to it. Diodon is an inhabitant of tropical seas; the fishes are sometimes called "sea hedgehogs," they are covered with a thick skin without scales, over which are distributed a large number of spines. They have the power of inflating the body, and assuming a globular form their spines become extended, like those of a hedgehog. Their jaws consist of a single undivided plate, and are admirably adapted for breaking off branches of corals, from which they principally obtain their food. Fossil remains of Diodon have been found in the tertiary limestones of Monte Bolca. The Pristodus of the Carboniferous Limestone agrees with the recent Gymnodont Diodon in its dentition, but there in all probability the resemblance ended. The recent fish has a bony skeleton and is covered with bony spines, the fossil was apparently cartilaginous, and no spines have been found which at all resemble those of Diodon. It is very likely that the similarity of the dentition may indicate a similarity of diet, the remains of coral are abundant in the limestone.

In addition to the genera of fossil fish-remains already mentioned and which have been previously described, there are others which have not received the same attention, but these in all probability may be included in one or other groups, already indicated. The peculiar spines, Cladacanthus and Physonemus, occur sparingly in the Limestone of Wensleydale. The relationship of these peculiar ichthyodoralites is little understood.

In conclusion—it may be drawn from previous observations, that the fishes occurring most frequently in the thick-bedded lower limestone of other parts of the British Islands are absent or only represented by dwarfed specimens. The great spines of Ctenacanthus and Oracanthus are not present. The great teeth of Orodus, most of the genera of the Cochliodonts, the large palates of Psammodus, and the teeth of the Petalodonts, have in each case become dwarfed and comparatively insignificant. They present the appearance of groups which have previously reached the climax of their existence and were gradually succumbing to a more or less unfavourable environment—with the advent of the coal measures they have almost entirely disappeared.

ON THE LEAD VEINS IN THE NEIGHBOURHOOD OF SKIPTON.

BY J. RAY EDDY, F.G.S.

Before directing attention especially to the subject of my paper, it is due to the Members to explain that it was first proposed that the Lead Veins in the Grit-beds of Craven should be considered, but ultimately the veins described by the present title were preferred. This change practically leaves me a somewhat barren subject, because the Cononley Lead Mine has been entirely abandoned for several years in the eastern part, and almost so in the western, and it is the only place near Skipton, where the regular working of a vein has been carried on.

A paper on the larger and much more interesting Mining field in Wharfedale may prove welcome on some future occasion when you may be inclined to extend your excursions to that district.

The main vein is part of a large "fault," the throw of which has never been truly ascertained by the miner, partly because the sides have been rarely seen, and further on account of the disturbed state of the strata where the walls of the vein have been proved. It is the most southern of all the lead producing districts of our county, removed some ten miles from the nearest mine, properly so called, and fourteen miles from those producing lead ore in the Grit-stone beds. These veins also proved the rare, perhaps the only exception in the investigations made by Mr. C. Moore, of Bath, which seems to establish the "existence of organic remains in the earthy matrix of mineral veins in the carboniferous rocks." Again, the main vein is the only one amongst the grit producing mines of Craven which has yielded lead ore in quantities commercially valuable, whilst traversing highly disturbed strata, and with accompanying masses of shale in the vein itself: the veins in the other mines requiring the beds to be comparatively regular to prove productive, and then as a rule becoming small and poor on the approach of the shale either as a "cheek" of the vein, or thrown in as a leader, or accompaniment of the vein.

The Cononley mines were worked very many years ago, certainly before the introduction of gunpowder into this district, but only to a shallow depth, except in one place. The workers were stopped in their progress by the combined drawbacks of too much water and too little lead ore. In one place however, on the crown of the hill, eastward, and near to Mason's shaft, they got down to the depth of our Upper Adit Level, or 24 fathoms from the surface at that point. Here the vein was poor.

Some time subsequent to 1830, Messrs. Hall, of Newcastle, began the deep adit level crosscut from a point in Nethergill, to the west of the village of Cononley, about 525 feet above the level of the sea, with the view of intersecting and draining the main vein at that depth. After driving through several faults and much disturbed ground for a distance of 90 fathoms, these gentlemen gave up the trial and the crosscut was continued on behalf of His Grace the late Duke of Devonshire. The vein was met with after a total drivage of 205 fathoms.

I will briefly state the principal levels and shafts in the mine before speaking of the nature of the vein itself. The deep adit driven east nearly to, and west to the ends of the mine: the middle level, 10 fathoms higher, originally driven from a rise eastwards and extended to near the east end, and westward beyond Taylor's shaft; the upper adit, 10 fathoms higher still, extending from the surface eastward the whole distance; and Briggs level, a superficial adit, begun at the surface east of the engine shaft and continued to the east end of the mine. Below the deep adit, the 15 fathom level was driven some distance east and west to a distance beyond Taylor's shaft, the 25 a short distance east and west of Engine shaft crosscut, and the 45 fathom level which extended but little from this crosscut. There is also an old adit crosscut driven from the south-west side of the hill in the Glusburn ground, with two small shafts upon it, but this does not communicate with the mine proper. The principal shafts are Taylor's, at the end of the main crosscut sunk to the deep adit level, eastward from this the engine shaft to the 45 fathom level below the deep adit; and Garforth's and Mason's shafts both sunk to the deep adit only. In this part of the mine an "inclined plane," or shaft, was extended from the surface to the deep adit eastward. Westward of the main crosscut are Remfry's shaft to the deep adit, and Good Hope shaft, which has of late years been sunk to a level about 10 fathoms below the deep adit.

At this, the western part of the mine, exists the only chance I know of at present for any further development of the Cononley Main Vein.

The principal crosscuts which have practically proved the worthlessness of the side veins north and south of the main fault vein are, eastwards, the old Glusburn adit crosscut, Brigg's crosscut, the middle level north and south, and the upper adit south; in the centre of the works the upper adit north, middle level south, deep adit north, and the 15, 25, and 45 fathoms crosscut south. In the west end, the deep adit south, and one north (not shown on plan).

Besides these works there have been drivages at the upper adit, middle level, and deep adit in the south vein which returned some ore under very different conditions to those observed in the main vein; and also an adit level driven and a shaft sunk into the Gib Hill, on a vein which never produced any ore; through this level and shaft—at a later date—the smoke from the smelting mill was conveyed for the purpose of facilitating a further condensation of the fumes.

The main vein has a general direction of 32° W. of N. Mag. varying from 45° W. of N. in the ore-bearing part of the lode to 27° W. of N. in the poor ends of the mine. The "underlie" or "hade" south-west in the latter is 20° from the vertical, and in the former about 10°. In depth, this vein should receive the south vein, which with a hade of 6° from the vertical to the north-east might have been expected to be a valuable feeder of the old vein, but both failing in depth this junction downwards has not been experienced.

Between the deep and the upper adits, the main vein varied in width from a mere joint to 5 or 6 feet; and in the bearing-length above the latter it increased in some parts to 20 feet wide or more, yielding ore in one place close to the surface clay.

Below the adit the good part of the vein produced lead ore to a depth of 8 fathoms, and a little to the 15 fathoms level under the adit, but practically the vein failed at the depth of 15 fathoms, or a total depth from the surface at the engine shaft of 50 fathoms.

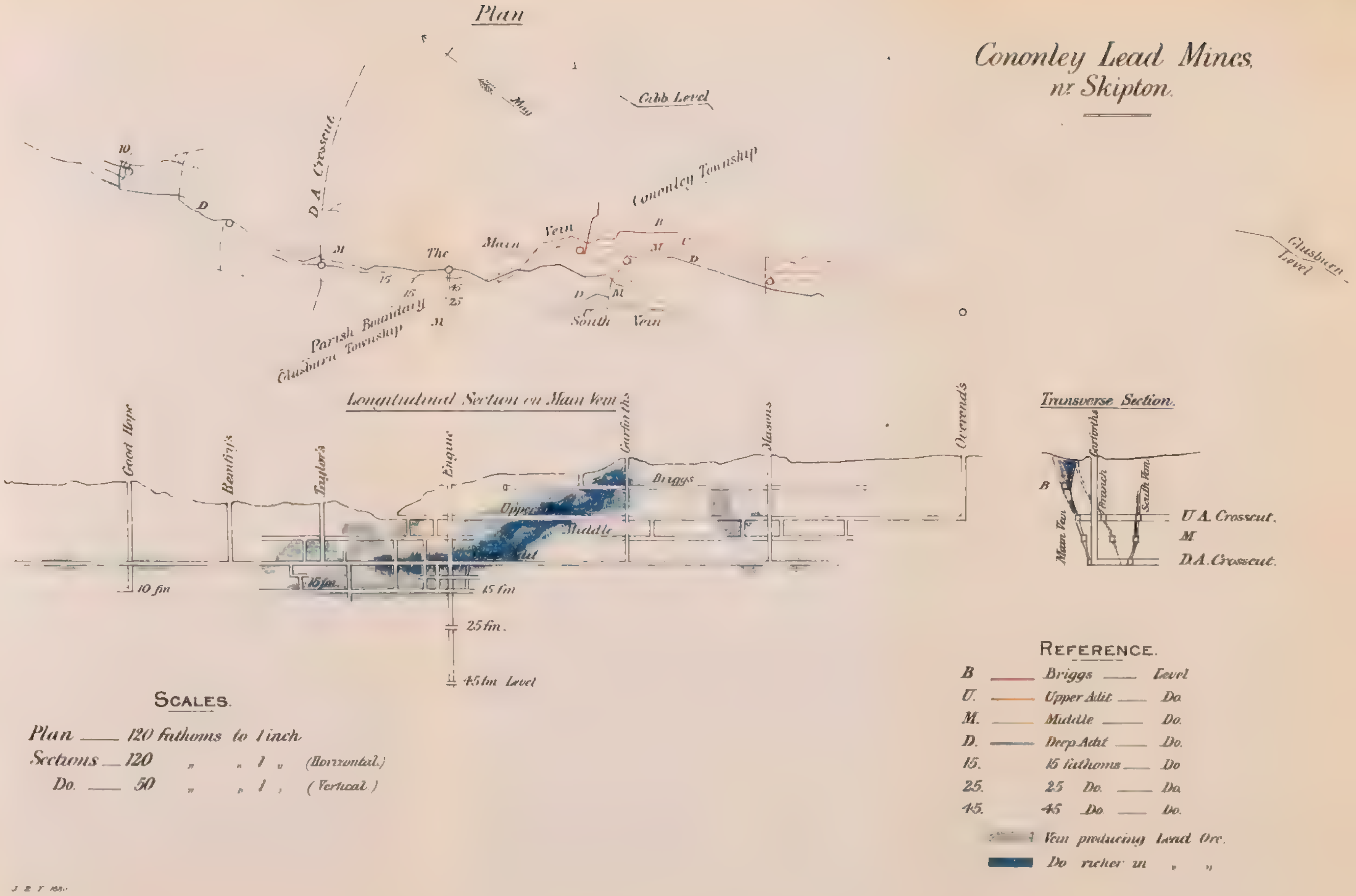
As will be seen from the plan the main vein was regularly productive for a comparatively short length of ground, the whole of the lode driven on east and west proving unremunerative, though not entirely barren.

In the productive channel of ground bounded by the main and south veins were several strings or smaller vein-branches, which leaving the old vein on its south side, robbed it, but not having strength to carry on to the south vein failed to enrich that lode east of the crosscut south of Garforth's shaft.*

---

* N.B.—On account of small scale of plan these strings and several other works are omitted.

Cononley Lead Mines,
nr Skipton.



The main vein above the upper adit widened out, and for a very short length on the north-west and near to Garforth's shaft was worked open to the surface.

The matrix of the vein being principally sulphate of barytes (heavy spar), and the substance of the wide part of the vein being intersected by "slants" or clay joints, the "stopping," or removing of this ground entailed considerable danger to the miners. In one part of the ground over the top level the vein-stuff was practically stratified, the matrix coming away in beds of one to three feet in thickness.

Besides the sulphate a lesser quantity of carbonate of barytes or "witherite" has been obtained. These with ochreous-marl, some calcite and much black clay have been the principal contents of this lode.

It is probably due to the large deposit of sulphate of barytes in the upper portion of this vein, that the water percolating through the mass of vein-stuff is so charged with sulphuric acid as to dissolve the good iron out of the tram rails, leaving the cinder in thin parallel plates as a tribute to the ability of the iron-master to manipulate other than good iron.

It is apparent that the main portion of the deposit of ore in this vein crops to the surface in the east-central part of the ground near Garforth's shaft, and dipping to the north-west is probably cut off by the "fault" known to range westwards, with the north side down.

The remainder of the deposit has been denuded and removed from the eastern and more elevated part of the ground, and I see no good reason for expecting that at any future time lead ore will be discovered in quantity further to the south-east.

The ore yielded by this vein was almost entirely the sulphide of lead, (or galena,) principally disseminated amongst the matrix of the vein throughout the width of the lode, and not often in solid masses. Being mixed with heavy barytes and some iron pyrites, the separation of the ore from the impurities was difficult, and its physical nature when prepared for the furnace made it most refractory in the smelting, very much more so than is usual in ores raised from mines in the same class of rocks.

The south vein—contrary to the characteristics of the main—had very little "throw," and regular cheeks or sides. It showed a north-east "underlie" of about 6°, and in the bearing part of the lode was of a width varying from a few inches to a foot. Its bearing is about 40° W. of N. Mag., bearing towards the main vein going westwards.

The junction, however, has not been seen in this direction, probably on account of the intervention of the "fault" before alluded to. This "fault" has not been recognised in the mine, for it is difficult and often impossible to see in the size of a level anything further than what appears a "backing" in the rock, whenever the "fault" is a mere joint.

The ore in the south vein was of a different nature to that from the main lode, being generally found loose in the vein, with little matrix, and that generally of friable carbonate of lime, with loose, dry, earthy mineral. In quality this ore was superior to that from the main vein, but unfortunately it fell far short in quantity.

The ore bearing zone was limited to a distance of about 18 fathoms, extending from the deep to a little higher than the upper adit, while in length the productive ground was still less than in the main vein.

In driving the middle level near Mason's shaft, the lowest part of the earliest works were met with, and in Brigg's level, east of Garforth's; a long length of old workings and a short crosscut were opened into. Here our predecessor had cut his ground with picks only, and every shift or day's-work could be accurately told by observation of the side of the level. Only in one place was a bore hole to be seen, and this was probably of a later date. The vein was filled with solid sulphate of barytes, but so hard that the modern miner had difficulty in even boring the ground. Probably the barytes had become somewhat harder by exposure to the air.

In the west end of the mine approaching Carleton Moor a trial has been in progress to trace the vein through the lower members of the Kinder-Scout grit into the limestone shales of the Carleton anticlinal. This has been a difficult matter, owing to the cross veins and the weakness of the right running veins. (Further trials in the western ground have shown considerable disturbance of the strata from the intersection of several "fault veins" in close conjunction, but though the mine has been closed I think the appearance of the vein just east of the disturbance justifies the hope that it would prove a productive one if it were explored west of the intersections, and in the settled beds which are known to exist there).

The total quantity of ore produced from the two veins is about 15,000 tons. The upper part of the old vein produced some carbonate of lead but not in quantity.

The only other places near, where any ore has been produced from the Kinder-Scout grit is at Cowling, about 1½ miles west of Cononley, where a trial was made and about 3½ tons of ore raised.

Trials were also made in the grit on Bradley Moor, and on Carleton Moor, but without success.

In the limestone of the district there are north and south veins running across theaxis of the Carleton Park-head and also of the Skipton Haw-Bank Quarries. From the former place, about 15 tons have been obtained, and from the latter, about 13 tons. These veins are very uncertain but carry ore of good quality in self lumps in the clay of the lode.

ON THE DISCOVERY OF FLINT IMPLEMENTS ON THE HILLS BETWEEN TODMORDEN AND MARSDEN. BY ROBERT LAW AND JAMES HORSFALL.

INCITED by the discoveries of Mr. J. W. Davis, Mr. John Aitken and others, a series of investigations were commenced by the writers in the Spring of 1879, to ascertain the distribution and mode of occurrence of Neolithic flints. The work has been carried on more or less successfully for three years. The places visited are the highest summits and most prominent hills in those parts of the Penine Range which lie within a radius of about twelve miles of Rochdale. The first locality visited was Dean Clough, a small upland stream about a mile north-east of Junction-in-Saddleworth, where one hundred and fifty flints were found; these consisted of chippings, flakes, one or two small cores and a beautifully worked barbed arrow tip. The flints were exposed on several small patches of dark stoney loam, the superincumbent peat, probably from ten to fourteen inches in thickness, having been removed by fire. Subsequent visits to this locality have resulted in the discovery of other flints, one of the most interesting being, an elegantly fashioned and most delicately chipped leaf-shaped arrow head, the point of which was long, sharp, and tapering (pl. III, fig. 2). It was found on the left bank of a small stream, about half a mile to the north of Dean Clough. This arrow head, when first seen, was sticking out from beneath peat about seven feet thick.

A little to the north of this stream a patch of bare ground was met with, about half an acre in extent, which after a careful search, yielded about 20 flint chippings and flakes, one of the latter had the appearance of having been ground to a sharp edge.

Flints appear to be so abundantly scattered on this elevated moorland, that in nearly every case where an opportunity was offered for an examination of the subsoil, one or more could be found. The most striking example was met with on March Hill, a conical eminence overlooking the Vale of Marsden.

This hill is completely isolated from the surrounding moors, and although of comparatively small dimensious more than two thousand flints were found on a few small patches of bare ground, on its southern side. The flints varied in size from chippings not larger than a pin's head to flakes two inches long. Several small flint cores and one leaf-shaped arrow tip with a broken point were also picked up. Indeed the number of small chips and flakes was so great, as to lead to the conclusion, that flint implements were manufactured there during "pre-historic times." It may be worthy of note, that while flints occurred in great abundance on the south side of the hill; the side facing the north, although there was much bare ground, only yielded ten pieces.

After every flint that could be seen on this hill had been picked up in the summer of 1880, we found on revisiting the place the following year, that another crop, as it were, had sprung up, for the bare ground on the south side of the hill was again strewn with flints. This occurrence might, at first, have thrown a little doubt on their antiquity, had we not removed a thin layer of soil, and found flints at a still lower level, and in this way convinced ourselves that they must have been laid bare by the denuding action of atmospheric agencies. Several small pieces of red ruddle (peroxide of iron) were found, which may have been used by the ancient men by whom the flints were worked.

After carefully examining the naturally bared surface, we dug at several places and exposed the following section:—

1. Peat, from ten to sixteen inches thick.
2. Dark Peaty-clay, from two to six inches thick.
3. Dark-grey Sand, with angular pieces of sandstone, all local, six inches thick. Flints occurred abunantly in this layer.
4. Red Ochreous sand, about twelve inches thick, resting on Yoredale shale.

It will be seen by the above section, that the true position of the flints was the dark-grey sand, No. 3, in which they occurred at all levels; it yielded from twelve to a hundred and twenty flints per square yard. Although the other layers were examined with equal care, not a particle of flint was found.

At this place a quartzite pebble was dug up, about two and a half inches in length, and an inch in breadth, which showed at each end distinct signs of having been used as a hammerstone. It was found in the grey-sand, beneath the thickest part of undisturbed peat.

Another quartzite pebble has lately been found on the moor, about half a mile south-west of March Hill, by Dr. March, of Rochdale, it is two and five-eights of an inch in length, and one and a half an inch in width, is thin and oval in form and has been bored through the centre, the operation having commenced from both sides of the pebble. It would appear from the position in which this bored pebble was found, that it was at one time under peat about three feet in thickness. (Pl. III, fig. 1).

About two miles east of March Hill, the most striking and prominent feature in the neighbourhood is Pule Hill. On its southern extremity, which is the most elevated part, about a dozen flint flakes were discovered; one of the most remarkable is about two inches in length and three eights of an inch in breadth; it is beautifully fashioned and may have been used as a knife. Near the foot of the hill a small patch of subsoil was examined and yielded upwards of two hundred fragments of flint and chert. They consisted of flakes, chips and cores, one of the former showed signs of having been delicately chipped along one side, in order to form a serrated cutting edge. It is two and a quarter inches in length, and one inch in its broadest part. (Pl. III, fig. 2).

At this place chert was more abundant than flint. Still further eastwards a few flints were obtained from Butter Hill and Waster Knab, they were all flakes, and only one showed distinct traces of secondary chipping.

While examining this part of the Penine Range, a sharp look-out was also kept for stones foreign to the district, which might indicate the presence of glacial *debris*, but not a fragment was met with.

Attention was next directed to an elevated and prominent ridge of moorland which lies about four miles west of Rochdale, and thence trends north-west to the neighbourhood of Burnley. On several points of this ridge flints have been discovered, the most interesting discovery however, was made on Middle Hill, near Whitworth. The opportunities for investigation on this hill were most favourable, owing to a considerable portion of its peaty covering having been burnt off some ten or eleven years ago. Since that time atmospheric agents have lowered the loamy subsoil at least an inch, as is proved by little earth-pillars capped with stones, seen here and there on its western flank. On the southern portion of the hill flint chippings, flakes, small cores and worked fragments, were so abundantly scattered over the bare ground that no less than three hundred and fifty have been gathered.

This contrasts strongly with the northern portion of the hill which, after a diligent search only yielded five flints. Many of the flints found at this place showed the bulb of concussion, others by secondary chippings have been fashioned into implements and weapons; of the former about twelve may be mentioned which have been worked into a circular form by chipping round the edges. They vary in size from half an inch to one and a half inch. Of the latter class, a perfect arrow head of the barbed type, delicately chipped on both faces, and a well formed javelin's head or knife have been found. The last named is about two and a half inches in length and three quarters in breadth, and has every appearance of having been much used.

About three per cent of the flints found on this hill appear to show the action of fire, their surfaces being traversed by small cracks bisecting each other at different angles. This leads to the inference that originally the flints were at different levels and are not all exactly of one age. Thus while those on the surface soil would be heated when it was burnt off, others buried in the underlying clay would be protected from such heat. At one or two places on the hill flints were seen sticking out of the loamy clay, while in other cases they were found capping little earth-pillars, thus indicating the position they occupied before the ground was bared.

The original covering of this hill consisted of a dry sandy loam, about eight or ten inches thick, which supported the growth of *bent*, a peculiar grass, rich in silica. This is proved by the occurrence at several points on the bare ground of small patches of soil which escaped the action of the fire referred to above. It will thus be seen, that the conditions for the formation of vegetable matter have been so unfavourable at this place, owing to the dryness of the ground, as to make it probable that the flints found there, though under so thin a soil, are quite as ancient as those occurring at much greater depths, in localities more favourable for the growth of peat. To the south, south-west and north of this hill, other prominent hills are located on which many fragments of flint have been found, among these, Knowl Hill and Bull Hill may be mentioned as being the most important on account of their having yielded implements undoubtedly worked by human hands.

A rather rude form of arrowhead with broken point, a flint core and a few chips have been found at Knowl Hill, while from Bull Hill we have obtained an arrow head with one of its barbs broken, one or two delicately worked bits of flint, and a few chips and flakes. On Bull Hill the flints appear to have been covered at one time with peat, varying from one to six feet in thickness.

From a ridge of high ground known as Midgley Moor about two miles north of Mytholmroyd, several flints have been obtained, among which a small leaf-shaped arrow head, a circular thumb-flint and two worked flakes, may be mentioned. The subsoil on which they were found, in almost every instance, has been laid bare by fires occurring from time to time.

In conclusion, it may not be out of place to call attention to one or two points in relation to the flints we have already discovered.

Firstly, the well-formed barbed arrow-heads and other well-worked flints were so associated with those showing little or no design, such as chips and flakes, to leave no doubt whatever on our minds that they all had a common origin and must have been fabricated by pre-historic man.

Secondly, in all cases the flint flakes and cores were of comparatively small size, which may be accounted for, on the supposition that this material was a scarce commodity among the ancient tribes who inhabited these hilly districts. This will seem all the more probable if we take into consideration the only two possible sources from which the flints could have been derived, viz., the Glacial Drift and far off Chalk districts.

Thirdly, so far as our investigations have yet gone, we have failed to detect any trace of polished stone celts, and in only two doubtful instances have ground or polished flints been observed. Had these ancient Britons been in the habit of using polished stone hatchets, it is not unreasonable to suppose that some fragments of them would have been left behind, especially at places where implements appear to have been made.

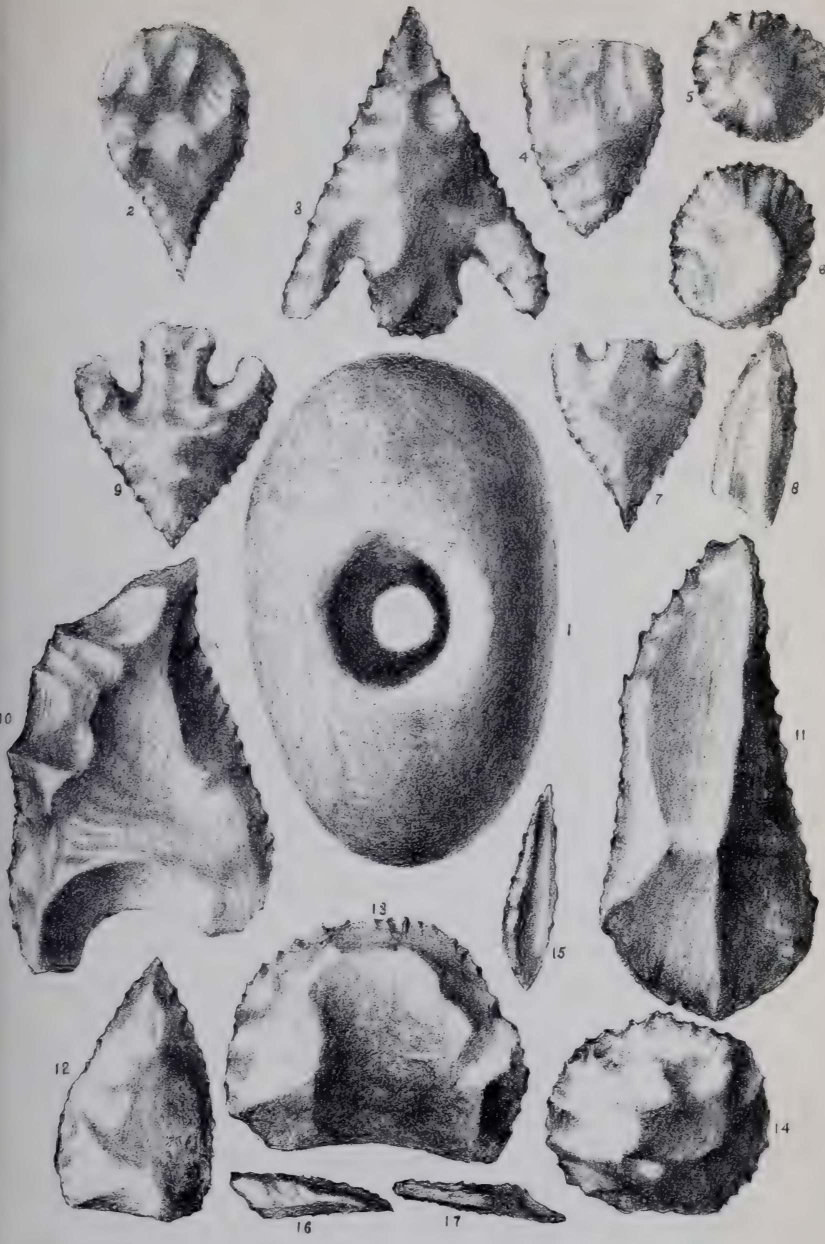
Lastly, two hills have been pointed out on which flints occurred more abundantly on the southern than the northern slopes, and this is true of almost all the elevated places where we have yet been able to detect flints. This may be explained by supposing the ancient men selected the more sunny and warmer side of a hill for carrying on the work of fashioning their tools and weapons.

The following table shows the approximate number of worked and unworked flints, and the places where they have been found.

PLACES WHERE FOUND.	NO. FOUND.	NO. WORKED.	NO. UN-WORKED.
Dean Clough, Saddleworth	300	8	292
Moor, North of Dean Clough	20	2	18
March Hill, near Marsden	2300	30	2270
Moor, South of March Hill, near Marsden ...	30	1	29
Pule Hill, near Marsden	12	1	11
Foot of Pule Hill, near Marsden	200	2	198
Butter Hill, near Marsden	10	1	9
Waster Knab, near Marsden	6	1	5

PLACES WHERE FOUND.	NO. FOUND.	NO. WORKED.	NO. UNWORKED.
Haugh Hey, near New Hey	4	0	4
Robin Hood's Bed, near Blackstonedge	10	1	9
Monshead Hill, near Ripponden	6	0	6
Studley Pike, near Todmorden	2	0	2
Basin Stone, Walsden, near Todmorden	2	2	0
Ramsden Clough, Walsden, near Todmorden ...	1	1	0
Foot of Ramsden Hill, Walsden, near Todmorden	1	1	0
Trough Edge, Walsden, near Todmorden ...	10	0	10
Hey Head, near Todmorden	1	0	1
Hades Hill, near Wardle	2	0	2
Middle Hill, near Whitworth	350	15	335
Brown Wardle Hill, near Whitworth	5	1	4
Rush Hill, Healey, Rochdale	3	1	2
Knowl Hill, near Rochdale	40	3	37
Bull Hill, near Ramsbottom	8	2	6
Whittle Pike, near Ramsbottom	1	0	1
Todmorden Moor	1	1	0
Wadsworth Cock Hill, near Hebden Bridge ...	9	3	6
Midgley Crow Hill, near Hebden Bridge ...	8	1	7
Cant Clough, near Burnley	1	1	0
Cold Edge, near Sowerby Bridge	8	0	8
Rooley Moor, near Facit	3	0	3
Brock-holes, Walsden	4	1	3
Crow Knowl Hill, near Shaw	4	0	4
Turnshaw Hill, near Rochdale	50	0	50
Hunger Hill, near Rochdale	12	3	9
TOTAL	3824	83	3741

We are indebted to Mr. John Evans, F.R.S. for kindly examining a number of our flint implements. He concurs with our opinion that they are pre-historic, but whether they belong to the Neolithic or Bronze age there is not yet sufficient evidence to determine. He makes a special allusion to some very small but delicately chipped flints, many of which have been found on March Hill, and informs us they are the smallest flint implements that, to his knowledge, have ever been found in this country; we are moreover told that a similar type of implements has lately been found in Egypt, Mr. Evans believes they may have been used as "carving tools." (Pl. III, figs. 15, 16, 17).



STONE AND FLINT IMPLEMENTS FOUND ON MOORS, NEAR TODMORDEN.

A. Mason & Sons, Leeds

YORKSHIRE FOSSIL MOLLUSCA. BY WILLIAM CASH.

THE organisms which in past ages inhabited salt or fresh water, are as one might expect, those which are preserved in the greatest numbers and in the best condition in the sedimentary rocks. The factors which appear to have favoured the preservation of marine and fluviatile animals as fossils, in quantity and variety, are:—

1. The hardness of the protective coverings or tests.
2. Their facility for undergoing mineralisation.
3. The quantitative development of genera, species, and individuals.
4. The variety of surrounding conditions, as to depth, horizontal distribution, &c., &c.
5. The early appearance on the earth, and continued persistence of forms during each successive geological epoch.

No sub-kingdom seems to have fulfilled these conditions better than the Mollusca, the hardness of their shells fitted them to resist a considerable amount of abrasion, and to defy the action of many tendencies to decay; their chemical composition (chiefly carbonate of lime) lent itself readily to changes in mineralisation; they abounded in the seas and lakes of the various geological periods, both in genera, in species, and in individuals,they flourished under the most varied climatal conditions, and were found at all depths; they appeared early on the theatre of the life history of the globe, and have held their own as a class to the present time. No wonder that they afford to the Geologist precious and most useful data for a philosophical interpretation of the world's early history.

Fossil Mollusca are well represented in the county of York, perhaps no equal area of land can be found to surpass Yorkshire in the variety and interest of its Geological strata, extending from the Silurian rocks in the north west of the county, through the Carboniferous area, and the wide vales of the Permian and Trias to the wonderful development of Jurassic and Cretaceous rocks on the east coat, with patches here and there of Post Tertiary beds,—and Fossil shells are to be found in most of these formations, in many instances in immense profusion; their value is greatly enhanced to the field geologist when they are found to be characteristic of particular strata and beds. this is found often to be the case, and this most notably in the so-called Ammonite Zones in the Lias, where the presence of one single Ammonite may be sufficient to indicate the exact stratigraphical position of a Geological stratum.

The following genera of fossil shells have been recorded for the county of York in Tate and Blake's Yorkshire Lias; Phillip's Geology of the Yorkshire Coast; Phillip's Geology of the Mountain Limestone District; Davis and Lee's West Yorkshire; the volumes of the Quarterly Journal of the Geological Society, &c.

No doubt some of these genera will be found on a careful study of specimens to be merely synonyms, others as the Ammonites, the Goniatites, some of the Lamellibranchs will require to be split up, at least into sub-genera.

GENERA OF YORKSHIRE FOSSIL CEPHALOPODA.

Teuthopsis	Jurassic
Beloteuthis	,,
Geoteuthis	,,
Belemnites	,,
Belemnitella	,,
Ammonites	
Amaltheus	Jurassic and Cretaceous.
Lytoceras	
Phylloceras	
Harpoceras	
Stephanoceras	
Œgoceras	
Arietites	
Cosmoceras, &c.	
Scaphites	Cretaceous
Hamites	,,

Ancyloceras	Cretaceous.
Crioceras	,, .
Helicoceras	,,
Orthoceras	Silurian, Carboniferous
Actinoceras	Carboniferous
Cyrtoceras	Silurian
Phragmoceras	Carboniferous
Nautilus	Carboniferous, Permian, Jurassic and Cretaceous
Lituites	Silurian
Trochoceras	Silurian
Goniatites	Carboniferous
Poterioceras	,,

YORKSHIRE FOSSIL GASTEROPODA (GENERA).

Bellerophon	Silurian, Carboniferous
Porcellia	Carboniferous
Murex	Jurassic
Trophon	Pleistocene
Fusus	Pleistocene
Pleurotoma	Pleistocene
Buccinum	Carboniferous, (?) Pleistocene
Purpura	Pleistocene
Purpuroidea	Jurassic
Columbella	Pleistocene
Natica	Carboniferous, Permian, Jurassic, and Pleistocene
Scalaria	Pleistocene
Nerinea	Jurassic
Avellana	Cretaceous
Actæonina	Jurassic
Cylindrites	Jurassic
Chemnitzia	Permian, Jurassic
Loxonema	Carboniferous
Macrocheilus	,,
Eulima	Jurassic
Solarium	Cretaceous
Discohelix	Jurassic
Phanerotinus	Carboniferous
Cirrus	,, Jurassic (?)
Euomphalus	,, ,,
Platyschisma	Carboniferous
Pleurotomaria	,, Jurassic, Cretaceous
Murchisonia	Silurian, Carboniferous

Straparollus	Permian
Trochotoma	Jurassic
Alaria	,,
Admete	Pleistocene
Rostellaria	Cretaceous
Hydrobia	Jurassic
Trichotropis	Pleistocene
Cerithium	Carboniferous, Jurassic, Cretaceous
Melania (?)	Carboniferous
Littorina	Jurassic, Pleistocene
Amberleya	Jurassic
Rissoa	Permian, Jurassic
Bithynia	Pleistocene
Valvata	,,
Holopella	Silurian
Turritella	Carboniferous, Permian, Jurassic, Cretaceous, Pleistocene
Nerita	Jurassic
Neritopsis	,,
Pileopsis	Carboniferous
Acroculia	,,
Capulus (?)	,,
Phasianella	Jurassic
Pitonellus	,,
Turbo	Silurian, Carboniferous, Permian, and Jurassic
Cryptæna	Jurassic
Eucyclus	,,
Monodonta	,,
Delphinula	Cretaceous
Trochus	Carboniferous, Jurassic, Cretaceous and Pleistocene
Emarginula	Cretaceous
Lepeta	Pleistocene
Puncturella (= Cemoria)	,,
Patella	Carboniferous, Jurassic
Dentalium	,, Permian, Jurassic, Cretaceous, Pleistocene
Chiton	Permian
Metoptoma	Carboniferous
Actæon	Jurassic
Bulla (?)	,,
Planorbis	Pleistocene

Limnea	Pleistocene
Succinea	,,
Limax	,,
Bulimus	,,
Zonites (= Helicella)	,,
Helix	,,
Cochlicopa (= Zua)	,,
Clausilia	,,
Achatina	,,
Pupa	,,
Vertigo	,,
Carychium	,,
Acme	,,

GENERA OF YORKSHIRE FOSSIL LAMELLIBRANCHIATA.

Pholas	Jurassic, Cretaceous, Pleistocene
Teredo	Cretaceous
Gastrochœna	Jurassic
Saxicava	,, Pleistocene
Solemya	Jurassic
Mya	Cretaceous, Pleistocene
Corbula	Carboniferous, Jurassic, Cretaceous, Pleistocene
Anatina	Jurassic
Pleuromya	,,
Arcomya	,,
Ceromya	,,
Thracia	,, Cretaceous, Pleistocene
Pholadomya	,, ,,
Cardiomorpha	Carboniferous, Permian
Goniomya	Jurassic
Myacites	Carboniferous, Jurassic
Homomya	Jurassic
Panopœa	,, Cretaceous
Gresslya	Jurassic
Mactra	Jurassic (?) Pleistocene
Lutraria	Carboniferous (?) Jurassic
Sanguinolaria	Jurassic
Sanguinolites (?)	Carboniferous
Tellina	Jurassic, Pleistocene
Donax	Pleistocene
Scrobicularia	,,
Venus	Jurassic, Pleistocene
Cytherea	Jurassic

Thetis	Cretaceous
Isodonta	Jurassic
Pullastra	Carboniferous (?) Jurassic
Cypricardia	,, ,,
Cyprina	Jurassic, Pleistocene
Sphœrium(= Cyclas)	Pleistocene
Pisidium	,,
Cardium	Jurassic, Pleistocene
Cardiola	Silurian
Isocardia	Jurassic, Cretaceous
Edmondia	Carboniferous
Tancredia	Jurassic
Unicardium	,,
Conocardium	Carboniferous
Protocardium	Jurassic
Artemis	(?) Carboniferous
Lucina	Carboniferous, Jurassic, Cretaceous
Cryptodon	Cretaceous
Corbis	Jurassic, Cretaceous
Opis	Jurassic
Cardinia	Carboniferous, Jurassic
Cardita	Jurassic
Unio	Pleistocene
Anadonta	,,
Astarte	Jurassic, Cretaceous, Pleistocene
Montacuta	Pleistocene
Anthracosia	Carboniferous
Mytilus	Carboniferous, Permian, Jurassic, Pleistocene
Modiola	Carboniferous, Jurassic, Pleistocene
Myoconcha	Permian, Jurassic
Hippopodium	Jurassic
Lithodomus	do.
Perna	do. Cretaceous
Avicula	Carboniferous, Jurassic, Cretaceous
Aviculopecten	Carboniferous, Jurassic
Gervillia	Carboniferous, Permian, Cretaceous
Bakewellia	Permian
Inoceramus	Carboniferous, Jurassic, Cretaceous

Corbicella	Jurassic
Crenatula	„
Pinna	Carboniferous, Jurassic, Cretaceous
Axinus (= Schizodus)	Permian
Trichites	Jurassic
Trigonia	Jurassic, Cretaceous
Posidonomya	Carboniferous, Jurassic
Pteroperna	Jurassic
Pterinea	Silurian, Carboniferous
Cassianella	Jurassic
Monotis	„ Permian
Myalina	Permian
Arca	Carboniferous, Jurassic
Macrodon	Permian, Jurassic
Cucullœa	Carboniferous, Jurassic, Cretaceous
Isoarca	Jurassic
Pectunculus	Pleistocene
Nucula	Carboniferous, Jurassic, Cretaceous, Pleistocene
Leda	Carboniferous, Permian, Jurassic, Pleistocene
Leptodomus	Carboniferous
Orthonota	Silurian
Pecten	Carboniferous (?) Jurassic, Cretaceous
Hinnites	Jurassic
Lima	„ Cretaceous
Limea	Jurassic
Spondylus	Cretaceous
Ctenodonta	Carboniferous
Anomia	Jurassic, Pleistocene
Plicatula	Jurassic, Cretaceous
Ostrea	„ „
Gryphæa	Jurassic
Sowerbya	„
Quenstedtia	„
Placunopsis	Cretaceous
Exogyra	„
Dianchora	„

The range of these Fossils in time in Yorkshire is shown by the tables following:—

SILURIAN.

CEPHALOPODA.—Orthoceras, Cyrtoceras, Lituites, Trochoceras.

GASTROPODA.—Bellerophon, Murchisonia, Holopella, Turbo.

LAMELLIBRANCHIATA.—Cardiola, Pterinea, Orthoneta.

CARBONIFEROUS.

CEPHALOPODA.—Orthoceras, Actinoceras, Phragmoceras, Nautilus, Goniatites, Poterioceras.

GASTROPODA.—Bellerophon, Porcellia, Buccinum (?), Natica Loxonema, Macrocheilus, Phanerotinus, Cirrus, Euomphalus, Platyschisma, Pleurotomaria, Murchisonia, Cerithium, Melania (?), Turritella, Pileopsis, Acroculia, Capulus (?), Turbo, Trochus, Patella, Dentalium, Metoptoma.

LAMELLIBRANCHIATA.—Corbula, Cardiomorpha, Myacites, Lutraria (?), Sanguinolites, Pullastra (?), Cypricardia, Edmondia, Conocardium, Artemis (?), Lucina, Cardinia, Anthracosia, Mytilus, Modiola, Avicula, Aviculopecten, Gervillia, Inoceramus, Pinna, Posidonomya, Pterinea, Arca (?), Cucullœa, Nucula, Leda, Leptodomus, Pecten, Ctenodonta.

PERMIAN.

CEPHALOPODA.—Nautilus.

GASTROPODA.—Natica, Chemnitzia, Straparollus, Rissoa, Turritella, Turbo, Dentalium, Chiton.

LAMELLIBRANCHIATA.—Cardiomorpha, Mytilus, Myoconcha, Gervillia, Bakewellia, Axinus, (= Schizodus), Monotis, Myalina, Macrodon, Leda.

JURASSIC.

CEPHALOPODA.—Teuthopsis, Beloteuthis, Geoteuthis, Belemnites (Ammonites = Amaltheus, Lytoceras, Phylloceras, Harpoceras, Stephanoceras, Agoceras, Arietites, &c.), Nautilus.

GASTROPODA.—Murex, Purpuroidea, Natica, Nerinea, Actæonina, Cylindrites, Chemnitzia, Eulima, Discohelix, Cirrus (?), Euomphalus, Pleurotomaria, Trochotoma, Alaria, Hydrobia, Cerithium, Littorina, Amberleya, Rissoa, Turritella, Nerita, Neritopsis, Phasianella, Pitonellus, Turbo, Cryptœna, Eucyclus, Monodonta, Trochus, Patella, Dentalium, Actœon, Bulla.

LAMELLIBRANCHIATA.—Pholas, Gastrochœna, Saxicava, Solemya, Corbula, Anatina, Pleuromya, Arcomya, Ceromya, Thracia, Pholadomya, Goniomya, Myacites, Homomya, Panopæa, Gresslya, Mactra (?), Lutraria (?), Sanguinolaria, Tellina, Venus, Cytherea, Isodonta, Pullastra (?), Cypricardia, Cyprina, Cardium, Isocardia, Tancredia, Unicardium, Protocardium, Lucina, Corbis, Opis, Cardinia, Cardita, Astarte, Mytilus, Modiola, Myoconcha, Hippopodium, Lithodomus, Perna, Avicula, Aviculopecten, Inoceramus, Corbicella, Crenatula, Pinna, Trichites, Trigonia, Posidonomya, Pteroperna, Cassianella, Monotis. Arca, Macrodon, Cucullœa, Isoarca, Nucula, Leda, Pecten, Hinnites, Lima, Limea, Anomia, Plicatula, Gryphæa, Sowerbya, Quenstedtia.

CRETACEOUS.

CEPHALOPODA.—Ammonites, (Cosmoceras, &c.) Belemnites, Belemnitella, Scaphites, Hamites, Ancyloceras, Crioceras, Helicoceras, Nautilus.

GASTROPODA.—Avellana, Solarium, Pleurotomaria, Rostellaria, Cerithium, Turritella, Delphinula, Trochus, Emarginula, Dentalium.

LAMELLIBRANCHIATA.—Pholas, Teredo, Mya, Corbula, Thracia, Pholadomya, Panopœa, Thetis, Isocardia, Lucina, Cryptodon, Corbis, Astarte, Perna, Avicula, Gervillia, Inoceramus, Pinna, Trigonia, Cucullœa, Nucula, Pecten, Lima, Spondylus, Plicatula, Ostrea, Placunopsis, Exogyra, Dianchora.

PLEISTOCENE.

GASTROPODA.—Trophon, Fusus, Pleurotoma, Buccinum, Purpura, Columbella, Natica, Scalaria, Admete (=Cancellaria), Trichotropis, Littorina, Bithynia, Valvata, Turritella, Cemoria, Trochus, Lepeta, Puncturella, Dentalium, Planorbis, Limnea, Succinea, Limax, Bulimus, Zonites (=Helicella), Helix, Cochlicopa (=Zua), Clausilia, Achatina, Pupa, Vertigo, Carychium, Acme.

LAMELLIBRANCHIATA,—Pholas, Saxicava, Mya, Corbula, Thracia, Mactra, Tellina, Donax, Scrobicularia, Venus, Cyprina, Sphœrium, (=Cyclas), Cyrena, Pisidium, Cardita, Cardium, Unio, Anadonta, Astarte, Montacuta, Mytilus, Modiola, Pectunculus, Nucula, Leda, Anomia.

From the foregoing lists we may form an idea of the comparative richness of the different formations of Yorkshire in fossil mollusca. It is my intention to present to the readers of the Yorkshire Geological and Polytechnic Society, from time to time, sketches of this molluscan fauna, and to take up the subject mainly in its Palæontological aspects. The first group proposed to be dealt with is the Cephalopoda, but before proceeding to any description of species we present the modern classification of the group as proposed by Dr. Paul Fischer in the Journal de Conchyliologie 3^{e} Série, Tome xxii. No. 1. Paris, 1882, where he says, "For a long time the Class of the Cephalopoda has been subdivided into two orders. 1st. The Dibranchiata or Acétabulifera. 2nd. The Tetrabranchiata or Tentaculifera. I think it is now necessary to adopt a third order, that of the Ammonea in which the characteristics are mixed, approaching to the Dibranchiata by the initial sac of the shell in which is found a siphonal cœcum whose extremity does not touch the walls of the sac, but differing from the Dibranchiata by the animal having been always protected by an external shell to which it adheres by the aid of an adductor muscle; and by the absence of an ink-bag. On the other hand, if the Ammonea resemble the Tetrabranchiata by their external shell, and the absence of an ink-bag, they are easily distinguished from them by their initial shell without scar, and by the existence of one or two solid pieces (Aptychus) found in the chamber of habitation. The order Ammonea ought therefore to be intercalated betwixt the

Dibranchiata and the Tetrabranchiata.

The order Dibranchiata comprehends two sub-orders. Octopoda and Decapoda. I think it possible to divide the Octopoda into Monocotylea and Polycotylea according as the arms bear a single row or several rows of suckers (2 in Octopus, 3 in Tritaxeopus). The Decapoda form 3 large groups founded on the structure of the dorsal internal pen, which is Cartilaginous with the Chondrophora, Calcareous but without a chambered rostrum or guard in the Sépiophora (Ex. Sepia) and terminated by, or built up of, a series of air chambers, traversed by the siphon in the Phragmophora (Belemnites, Spirula). The Chondrophora, which are the most numerous, may be re-divided after D'orbigny into Oigopsidæ (Ommatostrephes) and Miopsidæ (Loligo).

The order Ammonea is divided into Rétrosiphonata and Prosiphonata, as the neck of the siphon is bent in a backward or in a forward direction. The Rétrosiphonata have for the type the Goniatites; the Prosiphonata includes all the shells called hitherto Ammonites. When these are unfurnished with an Aptychus, or possess only a horny Aptychus, they form the section Anaptychidea; when their Aptychus is made up of two calcareous pieces, free or soldered together, they belong to the section Aptychida. Finally, the Anaptychida have been re-arranged by the shape of their first initial saddle into Latisellata and Angustisellata.

The order of the Tetrabranchiata is divided into Prosiphonata and Retrosiphonata after the direction of the siphonal neck. The Retrosiphonata comprehends two families, the Nautilidæ with chambers perpendicular to the axis of the shell, and the Ascoceratidæ in which the chambers are very oblique, becoming even sub-parallel to the axis.

Dr. Fischer's classification may be tabulated in the manner following:—

CLASS.—CEPHALOPODA.

I. ORDER.—DIBRANCHIATA.	
A. sub-order.—*Octopoda.*	
a. Monocotylea.	(Cirroteuthidæ, Eledonidæ).
b. Polycotylea	(Octopidæ, Tremoctopodidæ, Argonautidæ).
B. sub-order.—*eDcapoda.*	
a. Chondrophora.	
§ 1. *Oigopsidæ*	(Cranchiidæ, Chiroteuthidiæ, Thysanoteuthidæ, Onychoteuthidæ, Ommatostrephidæ).
§ 2. *Miopsidæ.*	(Sepiolidæ, Sepiadaridæ, Idiosepidæ, Loliginidæ).
b. Sepiophora.	(Sepiidæ).
c. Phragmophora.	(Belosepiidæ, Belopteridæ, Belemnitidæ, Spirulidæ).
II. ORDER.—AMMONEA.	
A. sub-order.—*Retrosiphonata*	(Goniatidæ).
B. sub-order.—*Prosiphonata.*	
a. Anaptychidea.	
§ 1. *Latisellata.*	(Arcestidæ, Tropitidæ, Ceratitidæ, Clydonitidæ).
§ 2. *Angustisellata.*	(Pinacoceratidæ, Amaltheidæ, Ammonitidæ, Lytoceratidœ).
b. Aptychidea.	(Harpoceratidæ, Stephanoceratidæ).
III. ORDER.—TETRABRANCHIATA.	
A. sub-order.—*Prosiphonata.*	(Nothoceratidæ).
B. sub-order.—*Retrosiphonata.*	(Nautilidæ Ascoceratidæ).

ON THE RECENT EXTENSION OF MINING OPERATIONS UNDER THE PERMIAN FORMATIONS. BY THOS. WM. TEW, ESQ., J.P.

I HAVE pleasure in again welcoming the Society to the historical old town of Pontefract. You met here on Thursday, the 4th November, 1869, under the presidency of Lord Houghton, and thirteen years have not dimmed the recollections of that visit, to those who were then present, or relegated to oblivion the discussions which took place with regard to the geological wealth surrounding this ancient Borough, and the division of Osgoldcross, of which it considers itself the chief centre of importance. We, as residents in the town and district, hope that the speculations then hinted at have been developing cautiously, but surely, towards commercial success and realization; and we trust that the members of this Society may find that during this interval of time, industry, energy and capital have been brought to bear in the development of our underground wealth; and that they may appreciate the progress which has been accomplished by this practical application of geological science since they last honoured Pontefract with a visit.

First allow me to thank the Honorary Secretary of this Society and yourselves, for the compliment you have conferred upon me, in requesting me to act as your Local President on this occasion. I ask your considerate forbearance and co-operation in undertaking the duties of this Chair. At the same time, I desire to assure you of my earnest wishes to promote the interests of this valuable Institution, with which it has been my privilege to be associated for upwards of twenty years.

After the exhaustive addresses of your past Presidents, the devoted attention to special subjects of the scientific members of this Institution, and the published papers in its transactions, it is difficult for an amateur Geologist, like myself, to discourse on a special subject; but with your permission, I will venture to make some remarks upon the geological aspects of Mining in this division of West Yorkshire.

When the Yorkshire Geological Society was first formed, in 1836, the coal measures of Osgoldcross were hardly known. A little surface coal called "Crow Coal," or "Wheatwood Coal," about Glass Houghton, was scratched up by "Diggers of Cole," as John Dee, in 1570, described this new art of getting coal. And of the rest of Yorkshire, even to those engaged in mining works, the coal measures were only guessed at, pretty much as rare old Leland mentions them in 1535:—"Though here be plenti of wood, "yet the people burne much yearth cole by cawse hit is plentifull, "and sold good chepe." Deep mining was not yet possible.

Whatever Leland's "Yearth Cole" was, or the substance used in 1535, and subsequently as 'fuel," as Newcastle coal used to be called, no one but he who lived into the 19th century, and who can now estimate the full consequence of the agency of coal in the extension of the Railway, Steam Vessels, and Steam-transport systems could grasp the mighty fact, that the "Mineralized Vegetable matter," which Chemists tell us is composed of "carbon, "hydrogen and nitrogen," could give such impetus to the energy and industry of the people of England, and an enlightened policy in favour of commerce and manufactures. By this "Much Yearth Cole, by cawse hit is plentifull, and sold good chepe," has the commercial prosperity of the West Riding been built up.

The output in 1868, the return quoted when the Society was here in 1869, was over 103 millions of tons of coal; it is stated for the year 1880 to be over 140 millions of tons; whilst our Steam Navy, which in 1860 used half a million tons, in 1880 needed more than two and a half millions of tons—twice as much as all the other Steam Merchant Navies of the world combined.

This is the silver age of discoveries, and the golden age of Mechanics; and the unmatched progress of this country has been due to the natural energy of the race of Englishmen, and the narrowness of the bounds within which its increasing families are enclosed, and to the cheapness and abundance of the coal.

According to Mr. Lupton, coal is workable at a depth of 5,000 or 10,000 feet; but the temperature of the earth at a depth of 980 yards will be equal to blood heat, and if the miners have to penetrate another 500 yards "Mineral substances will be too hot "for the naked skin to touch with impunity." Under such conditions science and mechanics will, I have no doubt, render the conditions of human labour at these depths quite possible; and although it would appear that our new coal fields lie at great depths below the surface of the ground, I feel sure that whenever circumstances require it, coal will be raised from greater depths than 5,000 or 10,000 feet, whilst new beds will be discovered as yet undreamed of. Therefore, in my humble opinion, many of the conclusions of the Royal Commission were founded on insufficient data.

We must, I think, throw off, further away than ever, the question of the exhaustion of the British Coal fields, and the prospect of national ruin.

But if Leland could live again, and realise the dimensions of the industry his "Yearth Cole" has achieved from his day to 1882, he might feel inclined to write a new Itinery with reference to coal.

On the 25th Feb., 1869, the Haigh Moor Bed of the Merefield Colliery, at Glass Houghton, was struck at 347 yards from the surface of the ground, and the coal was found to be 4 feet 7 inches in thickness, with one dirt parting of three inches in the middle of the seam. This Colliery is now in working order, and is capable of turning out upwards of 1,000 tons of coal in 24 hours.

At a depth of 280 yards from the surface, salt water, much salter than that of the sea, is found; specific gravity 1·082 compared with fresh water: temperature 60 degrees of Fahrenheit's thermometer: four fluid ounces on evaporation leave a residue weighing 150 grains in slightly differing proportions to the other, as follows:—

Chloride of Calcium.
" " Sodium
" " Magnesium.
" " Potassium.

Bromides a trace; Nitrates (from decomposed vegetable matter), Sulphates not a trace.

Again, at a depth of 347 yards from the surface, another basin of salt water is found—specific gravity 1·101: four fluid ounces on evaporation leaving solid ingredients weighing 170 grains, as under:

Cloride of Calcium.
" " Sodium.
" " Magnesium.
" " Potassium.

Bromides not a trace; Nitrates (from decomposed vegetable matter) Sulphates not a trace.

These Pontefract samples of water contain a large amount of Chloride of Magnesium but no Magnesic Sulphates. The salt water is found in stronger saltness at the bottom of the "Prince of Wales" Colliery; again, deep down in the Wakefield rock; and Mr. George Roberts, of Lofthouse, informs me, on the 5th October, 1882, at 352 yards from the surface, this reservoir of salt water has begun to ooze through the roof of a Colliery there, increasing in quantity, and becoming troublesome and expensive to to deal with.

In the analysis of the brine at the Ryhope Colliery, 556 yards below the bottom of the sea and 800 yards from high water mark,in March, 1871, the constituents were:—

	GRAINS PER GALLON.
Chloride of Sodium	6936·39
" " Potassium	39·55
" " Lithium	a trace
" " Ammonium	1960·00
Carried Forward	8935·94

	GRAINS PER GALLON.
Brought Forward	8935·94
,, ,, Calcium	8·96
,, ,, Magnesium	368·90
Iodide of ,, ...	0·08
Bromide of ,, ...	43·39
Carbonate of Iron	2·90
Total solids per gallon	9360·17
Specific Gravity ... ... 1·1	

This analysis of the Ryhope Brine is furnished by Mr. T. W. Embleton, of Methley.

These waters are stronger than the salt waters pumped up at Droitwich, and contain ingredients different to those of ordinary sea water.

When you last assembled in this Town Hall, Mr. John Rhodes, the thrice elected Mayor of Pontefract, had not reached the coal at his "Prince of Wales" Colliery, but on the 1st of August, 1872, the Haigh Moor Bed was reached, at a depth of 477 yards, or thereabouts, from the surface; the coal, with two dirt partings, is 5 feet 6 inches in thickness.

This excellent coal possesses many valuable properties. Its illuminating power, by the method frequently adopted by Gas Engineers, is 14·5 ; density 0·528 (air = 1). Percentage of olefiant gas and similar substances 6·50. The number of cubic feet of gas per ton of coal 8,612.

The machinery at the "Prince of Wales" Colliery is capable of raising to the pit bank some 500 to 600 tons of coal every day. The colliery is ventilated by the most approved fan, 40 feet in diameter, the fanners being 10 feet in width and making some 35 revolutions per minute.

In addition to the coal which the enterprise of the Mayor is bringing to the surface, there are at about 30 feet below the ground, valuable beds of clay from 12 to 15 feet in thickness, which when chemically and microscopically examined revealed abundant evidence of organic matter, and of the extinct Flora of the Carboniferous rocks, whose decayed fragments mixed with sediment, (and together forming seat earth or "clay") are now manufactured into bricks and terra cotta designs.

These magnificent kilns can turn out 100,000 bricks per week. The clay contains in 100 parts:—

Moisture	4·30
Organic Matter and combined Water	7·71
Silicia	53·61
Protoxide of Iron	0·72
Peroxide of Iron	3·68
Lime	2·02
Magnesia	1·34
Alumina	25·96
Alkalies, other substances and loss...	0·66
	100·00

In the sample sent, one or two small rounded nodules were found, which on analysis consisted chiefly of Carbonate of Iron.

The Aketon Hall and Featherstone Manor Collieries belonging to Mr. Geo. Bradley, situated by the side of the Lancashire and Yorkshire Railway are worked; the "Stanley Main" bed of coal, 6 feet in thickness, at a depth of 240 yards, and the "Shale Seam," 3 feet thick, at a distance of 220 yards from the surface; the fuel is of superior quality from each mine.

Additional works for *winning* the celebrated "Barnsley Bed," which has been *proved* at a distance of 300 yards from the surface, are now nearly completed. This bed, Mr. Bradley says, is found to be 12 feet in thickness, and its existence at Featherstone, is, I hope conclusive testimony that it will be found to the South and South-East of Pontefract.

In the strata intervening between the surface and the Stanley Main Coal at these Collieries, salt water is found at a depth of about 200 yards, indicating that the salt rock exists somewhere in Yorkshire, but where has not been proved.* The recent discoveries near Newcastle-on-Tyne may, probably at no distant day, lead to finding the salt rock on this coast, and if so, its importance cannot be over-rated.

---

* The salt has just been found at Middlesbro'.

Mr. Bradley, whom we have to thank for the development of coal at Aketon Hall, thinks it may interest this Society to know that ironstone ore has been found at Digby, in Lincolnshire, adjoining the Great Northern and Great Eastern Railways, and within 20 miles of the coast where it was supposed to exist. This ironstone being almost equi-distant (about 20 miles) from the sea and the Nottinghamshire coal field, will doubtless become a source of immense advantage to the towns and districts of the East Coast and of West Yorkshire.

On the 27th August, 1870, a little to the West of Pontefract. Messrs Ellison and Broadbent opened a new shaft at Syndale, and called it by the name of the "Whitwell Main Colliery."

The shaft, commenced on the 2nd February, 1869, was completed to the coal on the 19th August, at a depth of 228½ yards, and in rapidity of sinking, has scarcely a parallel. The beds of coal passed through, are the Shale Coal, 3 feet thick, and the Stanley Main coal, 7 feet thick.

On the 1st Dec., 1870, Messrs. Henry Briggs, Son & Co. (Limited) of Normanton, raised from their new pit to the surface, and screened and made ready for sale 1,006 tons of coal. The seam from which this tonnage was raised is the Stanley Main, to which three shafts are sunk. One shaft is used for pumping purposes, the other as an upcast, and the third is utilized as a downcast shaft and for coal drawing. This shaft is 12 feet in diameter, filled up with a pair of 18-inch cylinders, made by Messrs. Davy and Brothers of Sheffield. The cages are single decked, and carry two tubs of 10-cwt. each. This seam of coal is worked upon the long-wall system with banks of 30 yards in length, and single shifts.

The shaft used as the upcast shaft is 8-feet in diameter, and supplies to the workings 70,000 to 80,000 cubic feet of air per minute.

On the 20th April, 1873, the Hon. Robert Ashburton Milnes turned the first sod of a new coal shaft on the Frystone Estate of Lord Houghton, which is now, I believe, the nearest pit to the port of Hull, and the German Ocean. The Frystone Coal Co. pierced the Barnsley Bed, some 180 yards from the surface on 17th August, 1874. On the 5th May, 1875, they struck the Haigh Moor bed at 269 yards, and expect shortly to reach, at a depth of 451 yards, the Silkstone seam, at the same depth as the Wheldale Colliery, one mile off, and worked by the same Proprietors.

It is a very rich gas coal. The analysis of it (at Wheldale) gives,—

Cubic feet of gas obtained per ton	9,200
Tar, Ammoniacal liquor, etc., per ton of coal (avoird)	476lbs.
Carbonic Acid, Sulphuretted hydrogen	28lbs.
Coke, per ton of coals	1,480lbs.

The gas obtained has an illuminating power approximating to 17 candles, so far as could be ascertained by experiment on a small scale.

The specific gravity of the gas as compared with air calculated at a barometric pressure of 30 inches, and a temperature of 60° Fahrenheit is 0.51. The gas contains 5.6 per cent. of olefiant gas. It also contains the other usual constituents of coal gas upon which its lighting and heat-giving properties depend. The gas contains only traces of carbonic acid and no sulphuretted hydrogen.

This coal from the Silkstone bed is comparatively free from pyrites. It does not soil the fingers, and in appearance and physical properties possesses the characters of cannel coal. Its specific gravity as compared with water is 1·2811.

When carefully heated to bright redness, in a closed vessel, it gives 60.84 per cent. of coke, and after burning it leaves 3.02 per cent. of ash.

This new coal field consists of some 4,000 acres, and it is situated on the line of the North Eastern Railway on one side, and the river Aire in close proximity on the other side near Castleford, and about 2½ miles from Pontefract.

The Warren House or Barnsley bed of coal has been worked by this company for a distance of 2 miles in an easterly direction under the Magnesian Limestone, and is found there rising to the East at about an inclination of 1 in 77. The thickness of the Silkstone coal at Wheldale is 5 feet, and the coal is good and bright in appearance.

The shafts are each 15 feet diameter, which equals an area of 176$\frac{3}{4}$ feet square each. In each shaft there are 70 yards of stone tubbing to tub off the water: the ventilation is created by a furnace which produces 130,000 cubic feet of air per minute; the horse power of the furnace being 28 H.P.

The number of coal seams which have been found to be workable on the estates of Lord Houghton and Temple, under those Royalties will, before being exhausted, supply a weekly quantity of coal of 10,000 tons for a period of nearly 200 years.

The Winding Engines, Plant, etc., now laid down, are capable of drawing 1,000 tons per day when required.

If from the Romans we received the idea of facilities of transport and communications throughout Ancient Britain, (for the Romans were the constructors of roads and highways) so from the Railway Companies we have received the most perfect scientific applications for rapidity of locomotion; and this district is benefited by this development of transport enterprise.

The Swinton and Knottingley Branch of the Midland and North Eastern Railway was opened for traffic on July 1st, 1879; the first sod of the Hull and Barnsley Railway was dug by Lieut-Col. Smith, the Chairman of the Railway Co., on Saturday, the 15th Jan. 1881; and the works on the line, generally, commenced about 1st Feb., 1881. The line, at present in course of construction, is about 50 miles long, and it is to be ready for inspection by the Board of Trade towards the end of 1884. The contractors, Messrs. Lucas and Aird (to whose representative we are indebted for an inspection at Upton of the Railway cuttings to-day) have brought mechanical contrivances to work, such as Steam Hydraulic

Navvy's, and Steam Grabbers, at the Dock, and elsewhere, which have enabled the contractors to construct this railway with a rapidity of growth, "like Jonah's gourd." This railway extension runs across the upper portion, so to speak, of the South Yorkshire coalfield, as the district is sometimes described, and for the present will stop at Halifax.

These two railways, North and South, and East and West mean a complete metamorphosis of Osgoldcross, not less remarkable than that which took place when the famous Roman Sixth Legion, about A.D. 117 marched from Danum to Legeolium—from Doncaster to Castleford, and nearly parallel with the Railway route by Ackworth to Doncaster. These two railways open out the new Yorkshire and Pontefract coal field of the future, of which deep shafts at South Kirkby, so energetically worked by Mr. John Shaw are the newest indications. What Merefield, Prince of Wales, Wheldale and Frystone, and the Manor Collieries of Mr. Bradley, at Featherstone, are to the Northern and Western sides of Pontefract, divided as it is by the sandstone ridge, on which the Town and Castle stand, so are these South Kirkby shafts, evidences of an extensive, valuable, and inexhaustible coal field to the south of the Borough.

The South Kirkby Colliery has two shafts, both 15 feet diameter—one as the upcast shaft, and the other as the downcast, and both are sunk to a depth of 640 yards.

The first bed of coal worthy of mention is the Shafton, found at a depth of 184 yards below the surface of the ground.

Section.	Feet.	Inches.
Coal	0	4
Dirt	0	1
Coal	1	0
Dirt	0	3
Coal	3	3

or a total thickness of 4 feet 7 inches of coal.

The bottom coal of this bed is of moderate quality for engine and brick making purposes; but as it burns to a white ash, it is not generally appreciated for domestic purposes; the two top beds of this Shafton coal, 1 foot 4 inches thick, are of inferior quality.

The next bed of coal worthy of mention before the Barnsley bed is reached, is the Kents Thin, or Bottom, or Best coal of the Stanley Main seam. It is 3 feet 2 inches thick, and of good quality for domestic use; but the other beds of coal, forming the Stanley Main Coal in the Normanton district (viz: the Lime Coal and Black Bands), are separated at this Colliery by many yards of parting or measures.

The famous Barnsley bed of coal is reached at South Kirkby at a depth of 634 yards, as per section:—

	Feet.	Inches.
Top Soft Coal	3	10
Dirt Parting	0	7
Hard Coal	2	9
Bottom Soft Coal	2	5
Total	9 feet, 7 inches.	

The following are the results of a careful analysis of the Barnsley Soft Coal, obtained from the South Kirkby Colliery, for gas making:—

Cubic feet of gas obtained per ton of coal ...	8,960 cubic feet.
Tar, Ammonical Liquor, &c.	408 lbs. (avoirds)
Carbonic Acid ... ... Sulphuretted-hydrogen	18·1 ,, ,,
Coke and Ash	1,495 ,, ,,

The gas obtained has an illuminating power approximating to 15 candles so far as can be determined from the quantity of coal operated upon.

The specific gravity of the gas as compared with air at 30 inches Bar. and 60° Fahrt. is 0·45.

The gas contains 4·8 per cent. of olefiant gas, or of substances of the same composition as olefiant gas.

As prepared and purified in the test apparatus by Mr. Thomas Fairley, F.R.S.E., of Leeds.—24th October.

An analysis of the Barnsley Hard Coal for gas, gives the following results:—

Cubic Feet of Gas obtained per ton of coal	10,400
Tar, Ammoniacal Liquor, &c.	41·25 lbs. (avoird)
Carbonic Acid	13
Sulphuretted hydrogen	
Coke and Ash	1504

The gas obtained has an illuminating power of 14·75 candles, so far as can be determined by the quantity of coal operated upon.

The specific gravity of the gas is ·41 (air=1).

The gas contains 4·5 per cent of olefiant gas, or of substances of similar composition. It was free from carbonic acid and sulphuretted hydrogen.

The coal is much harder than the other samples. Its specific gravity is 1·283. When heated in a closed vessel it gives 61·46 per cent. of coke, and when burnt leaves 4·28 per cent. of ash.

The sulphur separated from the gas from these coals in the test apparatus is, from the Fryston coal, 2·9 lbs. per ton; from the South Kirkby Colliery Soft Coal, 0.75 lbs.; and from the Hard Coal, 0·6 lbs. per ton.

This coal bed, 9 feet 7 inches in thickness, is extraordinary as compared with the generality of the coal of the Barnsley bed, and is equal in quality to other specimens of coal in the Barnsley coal field.

The upcast shaft is already sunk to this deep coal bed. and the downcast or drawing shaft is sunk to a depth of 400 yards; while it is expected to reach the coal about April, 1883.

Both shafts are cased with cast-iron tubbing, of which about 1,500 tons have been used to a depth of 126 yards.

The drawing engines are a pair of 42 inch cylinders, and 6 feet stroke; the nominal horse-power being 400 for the pair; and 10 boilers, each 30 feet by 7 feet.

At the drawing shaft, peculiar and novel modes both of winding and loading coal are to be used, whereby it is expected that the quantity of coals drawn up will be greatly augmented. For the purpose of ventilation at the upcast or air shaft, a Tchiele

Fan of 13 feet diameter is in course of construction to be driven by a pair of engines of 26 inch cylinders with a nominal power of 70 horses each. The capacity of the fan will be equal to about 250,000 cubic feet of air per minute.

This immense undertaking will involve an outlay of about £130,000. At Wheldale, the Barnsley bed is 202¾ yards below the ground surface; at Merefield Colliery, 254 yards; at South Kirkby, 634 yards; and at Denaby Main, near Conisbro', this splendid bed is successfully worked at a depth of 449½ yards.

Lastly, let me mention the probable extension of the Yorkshire coal field beneath the Magnesian Limestone and the New Red Sandstone, on the north side of the river Aire, and on the line of the Hull and Barnsley Railway, near Snaith, by Lord Beaumont of Carleton Towers.

A bore hole has been put down under the direction of Mr. Greaves, about 11 miles eastward of the Fryston Colliery, and two miles from Snaith, at West Bank, to a depth of 400 yards with the following results, viz:—

Earth, warp, and clay	15 yards.
New Red Sandstone	180 ,,
Upper Permian Marls ... ... Red Marls with beds of Gypsum	23 ,,
Upper Permian Limestone ... ... Limestone with some bands of Gypsum ...	28 ,,
Middle Permian Marls ... ... Red Marl with thin bands of Limestone and Gypsum	41 ,,
Lower Permian Limestone...	68 ,,
Coal Measures, Sandstone, Blue Shale, Black Shale, Coal, 1 foot 6 inches, Spavin and Blue Shale	45 ,,
Total,	400 yards.

Unfortunately, the boring stops short without reaching the Barnsley bed, which is believed to be a little lower down, because the contract for boring was only for this depth of 400 yards.

Mr. Greaves allows me to show a specimen of the Gypsum, which, if brought to the surface as a marketable commodity is valued at 1s. 6d. per ton, the inside core of the bore-hole being four inches in diameter.

The sub-division of the Permian Rocks occurs in the order in which they have been observed to crop up to the surface—they have each their usual character.

"There can be no doubt," says Mr. Greaves, "that the beds penetrated beneath the Permian Rocks are coal measures, and there are strong indications for believing that they belong to that part of the coal measures which contain workable seams of coal." The general character of the measures, the few fossils brought up in the cores, the clean and lustrous character of the thin seam of coal which has been passed through, all point to this conclusion; and that in the future the best portion of the Yorkshire coal field will be found between Barnsley and Snaith.

We shall hope that Lord Beaumont's restoration to health will enable him to continue this spirited investigation for coal, near Snaith, and that Mr. Greaves, the able and scientific pioneer of these sinking operations, may, at no very future date, be able to announce a discovery, that Lower Osgoldcross of 58,000, and Lower or one half of Barkstonash of 34,000 acres may be added as new coal fields to others in the County of York.

The Aire and Calder Navigation was opened in 1787; and the Knottingley and Goole Canal in 1826. The tonnage now reaching Goole, arriving and departing by this Canal in 1880, was above 392,000 tons. The return for the port of Hull and Dock Company, from January 1st to 31st October of the current year, dues was equivalent to 2,100,358 tons; and increase over 1881 of 214,388 tons; whilst up to the 31st October, 1882, the export of coal had increased by 68,000 tons.

THE PHOTOGRAPH FOR 1882.

THORNWICK BAY, FLAMBOROUGH. BY G. W. LAMPLUGH.

THE Photograph for this year is an excellent view of THORNWICK BAY, a little inlet on the northern side of Flamborough Head. The spectator is standing under the shadow of the cliffs on the west side of the "Bay," and looks due east across to the opposite headland.

The height of this headland is 150 feet. As will be seen, it is thoroughly riddled with caves and gullies, there being no less than seven caverns within the limits seen in the photograph,—and two long deep gullies which were probably once arched caves like the others. They are generally excavated along master-joints.

It is low-tide, and the beach in the foreground is strewn with rough blocks of chalk from the cliffs, with a thin scattering of darker transported masses from the boulder-clay; all covered with a plenteous growth of sea-weed, except near high-water mark. The weed is chiefly, but by no means wholly, the common Bladder-wrack *(Fucus vesiculosus)*.

The headland shows hard flinty chalk, capped with glacial drift of considerable thickness.

The Chalk contains much flint in irregular nodular layers; fossils are of rare occurrence,—here and there a large Inoceramus *(I. Cuvieri ?)*, an Echinoderm crushed beyond recognition, or a small Terebratula. The chalk dips gently south. The darker tint of the rock at the base of the cliff, within reach of the waves, is due to weathering and organic growth, and marks the limit of high tide.

The Drift is, as usual, complicated and variable, but the following section may be made out :—

At the top, 1.—Red boulder-clay (about 10 feet).
2.—Drift Gravel, very intermittent.
3.—Thick greenish or greyish boulder-clay, full of small pebbles but with a few large stones: often showing indistinct bedding, and appearing to pass into the gravel above and below it: fragments of marine shells plentiful in places.
4.—Drift gravel and sand; not seen on the headland, but well developed in the cliff near the middle of the bay.
5.—Fine angular chalky gravel or "wash" (possibly pre-glacial).
6.—Hard flinty chalk.

Though the beds above the chalk vary considerably both in thickness and composition, this section may be taken as a type of the geological structure of Flamborough Head.

I suppose the shape of The Head,—a blunted triangle, almost a cone, with its apex pointing due east, is known to all who will look on this picture. The cliff-line which forms its southern boundary, commencing near Bridlington and running east and east-north-east for five miles before the eastermost point is reached, pursues throughout a tolerably even course. But as soon as the projection is rounded and the coast faces north, a great and sudden change takes place, and the cliffs are indented and broken to such a degree, that from the Light-houses (which stand on the extremity) to the scene of the photograph, and for a little way beyond,—a distance in all of nearly three miles—the shore presents one long series of grand coast pictures, and we pass, step by step (where the tide allows), through caves and arches; into bays, and gullies, and nooks of ever-varying outline, with crannies and recesses innumerable; whilst here and there a massive rock-pillar stands sentinel-like apart. Add to this a clear and rollicking sea, dotted with many sail—one or two large steamers passing, no doubt, almost within hail—and occasional glimpses of the bold headlands of the coast-line stretching northward to Whitby—and you have, I think, as glorious a view as any on our Yorkshire coast.

Where the cliff is thus broken, its height nowhere exceeds 150 feet, but as we follow its course westward, it resumes its regularity, and rises somewhat swiftly to 250 feet, and then more slowly, till at Speeton, about five miles from Thornwick Bay, where the coast-line swerves northward and thus marks out the headland, the total height of the cliff is 444 feet.

The sudden change in the character of the coast at the eastermost point is not difficult to explain, and is due to more causes than one.

In the first place, the force of the sea is far greater on the exposed north than on the sheltered south side of the headland, and a violent tide-course also strikes it and is deflected eastward.

Then the upper flintless chalk,* which forms the cliffs between Bridlington and Flamborough, is soft and shattered, and yields readily to the waves all along the line ; but at the headland, flints put in an appearance, and the chalk becomes extremely hard and unyielding, and withstands the attack of the sea so well, that differences of resisting power have time to produce great results, and all the weak points, along joints, or where the beds are crumpled or shattered, are carved out.

There is still another cause. It will be noticed in the photograph that the old chalk surface below the drifts slopes inland, so that while the chalk is 90 or 100 feet thick on the headland, it is not more than 8 or 10 feet in the recess, part of this decrease, however, being due to the rise of the beach. This is really the northern slope of a valley which, in pre-glacial times, has run almost parallel with, and at no great distance from, the present cliff-line. This valley, which has been filled with drift and nearly obliterated during the Glacial Period, follows the northern coast-line of The Head to its extremity, and there runs out, being cut across where the cliff swerves south-west for Bridlington. Lateral feeders seem to have run into it from the north-east; indicating a wide extension of land in that direction.

This old valley causes some of the finest features of the coast.

---

* This upper chalk contains a fair number of fossils, chiefly sponges.

for when the sea tunnels back into its weathered slopes, they yield readily, and in two cases the waves have actually burst through into the drifts which fill the hollow, and as these have been of course readily scooped out, circular chasms—pot-holes in fact—have been formed in both cases, some little distance from the cliff. One of these is small enough to act as a "blow-hole" in rough weather, the sea choking up the vent till the imprisoned air bursts out with much noise, driving upward a cloud of spray.

There are a few lateral crevices, connected with caves, that "blow" in the same way. Goethe must have seen something like this:—

> "*Und die langen Felsennasen*
> *Wie sie schnarchen, wie sie blasen!*"*—(*Walpurgisnacht*).

After all, I cannot tell which is the finer picture—the fantastic ruggedness of this part of the coast, or the simple grandeur of the precipice beyond, where the great grey cliffs hang in a straight unbroken wall above the waves that lap and lash far below.

There, in the spring and early summer, countless swarms of sea-birds take up their abode—guillemot, razorbill, puffin and kittiwake—and pass continually in and out, like bees to a hive.

Not always is this little bay so bright and pleasant as you see it here, for—

> "Sometimes the sea takes a passionate tone
> And roars and raves in an angry mood."

Even while I write such a mood has come upon it, and this is what has taken place on the very spot:—

The schooner *Cheval de Troie*, of Guernsey, Captain Marriette, with a crew of six, bound for Shields from Dover, in ballast, was caught in the gale and snowstorm of December 6th, off Flamborough Head and driven unobserved on these rocks.† Her crew having lost all reckoning and not being able to see a cables-length ahead, had already taken to the rigging when the vessel struck; and one, Nicholas Williams, who was above the others, was flung oft into the sea by the shock. He lost consciousness, but was no doubt carried directly ashore. When he gained his feet and looked towards the ship, he saw that her masts had gone over the side, and her hull also immediately broke up, and disappeared. Of the rest of the crew he saw nothing. He was much bruised and exhausted, but made his way up the cliff and reached a farm house not far inland, carrying the first and only news of the disaster.

---

* "The giant-snouted crags, ho! ho!
How they snort, and how they blow!"—*Shelley's Translation.*

† From the wreckage brought ashore she seems to have first struck close to where the boat is seen in the left foreground of the photograph, and afterward to have shifted a little further west.

A little later in the day, the large collier steamer, *Black Diamond*, went ashore three miles further south. Her crew of sixteen were saved by the coast guards by means of the rocket-lines.

Such is an oft repeated chapter in the history of these pleasant cliffs.

ON SOME SECTIONS EXPOSED DURING THE FORMATION OF THE LINE OF RAILWAY BETWEEN UPTON AND KIRK SMEATON. BY JAMES W. DAVIS, F.G.S.

THE new line of railway at present in course of construction between Hull and Barnsley has exposed many sections of considerable geological interest. Amongst the most interesting is an exposure in the cuttings and tunnel near Kirk Smeaton, showing the junction of the coal measures with the superimposed magnesian limestone. The number of sections exhibiting the same arrangement are not very numerous. An instance occurs at Conisborough Castle where an outlier of sandstone forms a hill which is covered with Permian Limestone on which the castle is built. At Bramham Park, Knaresborough, and some other places, similar sections occur. In some sections the limestone rests on sandstone, and in others, on members of the coal measure series, but at the places last named the limestone lies above millstone grit rocks. It frequently happens that the sandstone or shale beneath the limestone is stained a reddish or purple colour, and the rocks so stained were considered from this circumstance to have been new red sandstone, the equivalents of the German *rothe–todte–liegende.* In the volume of "Proceedings" of this Society issued for 1877, I contributed a paper on "The unconformability of the Permian Limestone to the RedRocks below them," in which a somewhat detailed account is given of the occurrences, of such sections and circumstances attending their occurrence, along the line of the Permian escarpment, reaching in an almost north and south direction across the length of the county. In the present paper I propose to give a description of the sections exposed during the formation of the railway cutting, with a sufficiently detailed account of the immediately surrounding district, to make them intelligible.

The coal measures in the immediate vicinity consist of the upper measures exposed in the West Riding, and include a series of sandstones and shales, with beds of coal not at present worked in the district, though they are at short distances where railway accomodation has been accessible. The surface is characterized by gentle undulations, caused by the alternation of sandstones and shales dipping in the main eastwards with a north and south outcrop towards the west. The sandstones are not generally sufficiently thick and prominent to form escarpments such as characterise those of the lower measures westwards, but having resisted denuding agencies to a greater extent than the shales, remain to form the higher ground, whilst the hollows indicate the localities where the shale comes to the surface. The uppermost bed of sandstone exposed is the Houghton Common or Pontefract rock. It is the sandstone on which the Castle at Pontefract is built, and it extends round three sides of the hill, a fault running from Tanshelf roughly in a line with Causeway Lane to the south-west, throwing it out in that direction. South of Pontefract there are a series of sandstones occupying the surface around Ackworth, which are described in the Memoirs of the Geological Survey as the "Ackworth Rocks." Near the village they have been cut through by the River Went, exposing the shales beneath. A tributary of the Went running between East Hardwick and Went Hill also exposes the shales in a similar manner, the Ackworth Rock capping the slight elevation of East Hardwick on the west, and on the east immediately underlying the Permian Limestone escarpment forming the western boundary of Went Hill to Wentbridge and for some distance south of the deep channel formed by the river. This sandstone on the Geological Survey Map, 87 N.E., is indicated as a "Lower Red Sandstone and Marl," and considered a member of the Permian and Magnesian Limestone series. Later researches, as already stated, have proved that this is not the case, but that it is a sandstone of the coal measure epoch which has been stained by the superincumbent limestone a reddish or purplish colour. South of the Went, the whole of the district round Badsworth and South Kirkby is composed of shales with occasionally thin beds of raggy sandstone. Westwards of Hemsworth a sandstone occupies the surface extending to Brierley, called the "Brierley Rock;" and south-eastwards forming a semicircular patch, is an expansion of the Houghton Common or Pontefract rock, reaching to Clayton-in-the-Clay. Near Cudworth the line of railway cuts through some of Chevet Rocks, which along with the Oaks Rock are considerably developed towards Barnsley.

After the deposition of the coal measures a long interval elapsed before the Permian Limestone formation was deposited. The coal measures which had been evenly and uniformly accumulated above the millstone grit rocks over the surfaces now known as Lancashire and Yorkshire became subject to great displacement by subterranean agencies; the hills dividing the two counties were forced into existence, and during the process the whole country, east and west of the great central line of elevation was broken by innumerable faults, extending in every direction. These are especially frequent in the higher beds of the series where the measures are less persistent and more rapidly divided by alternating beds of shale, sandstone and coal. These strata being thinner were necessarily more easily influenced by the distributing force, and being further removed from the line of elevation and near the centre of the trough-like synclinal, had not only the pressure from the west to resist, but also that of the comparatively little influenced tract to the eastwards, which caused them to be broken into innumerable cube-like masses, whose relative lateral positions were much changed and faulted.

Subsequent denudation removed great masses of the much broken strata and planed it down to more or less even surfaces before the deposition of the Permian Limestones. This is amply proved by the position which these limestones occupy with regard to the underlying beds. The millstone grits, after extending in a north and south direction from Derbyshire to the neighbourhood of Halifax, make a great curve eastwards, and the whole of the district west of the Permian Escarpment, north of Leeds to the boundary of the county is composed of these rocks. The several sandstones and shales included in the divisions known as the "Rough Rock," immediately below the coal measures, the third grits, at Plumpton and Spofforth, and the equivalents of the Kinder Scout Grits the lowest beds, occuring in the neighbourhood of Ripon and northwards, successively disappear beneath the limestone escarpment with a southerly dip and a strike east and west; the opposite direction to that of the superimposed limestone. South of the neighbourhood of Leeds the successive beds of the coal measures dip under the limestone, always unconformably, the sequence of the strata from the lower coal measures north of Leeds, to the uppermost beds the Red Rocks at Rotherham, being successively obscured.

In the West Riding the Permian rocks consist of the following beds:—

Upper Marls with Gypsum and Sandstone.
Upper Limestone.
Middle Marls with Gypsum.
Small Grained Dolomite.
Lower Limestone.
Quicksand.

These rocks extend with varying modifications in a long narrow strip, rarely more than four or five miles in breadth from east to west, from Nottinghamshire through Yorkshire into Durham in a N.N.W. and S.S.E. direction. They usually present an escarpment to the westward, overlooking the undulating surface of the coal measures. The limestones dip towards the east beneath the New Red or Bunter Sandstone. The junction of of the two series is rarely visible, being covered by a considerable thickness of drift, the latter in great part composed of the denuded Permian Limestone. The Lower Limestone occupies the surface of the ground from Upton to the River Went beyond Kirk Smeaton, a distance of nearly four miles. The Quicksands which are in some localities, as at Garforth, of considerable thickness, occur sparingly. On the east bank of the River Went the Middle Marls occur on the slope of the hill surmounted by the Upper Magnesian Limestone, the latter being about one mile in breadth. The junction of the two may be seen in the cutting about 100 yards east of the river.

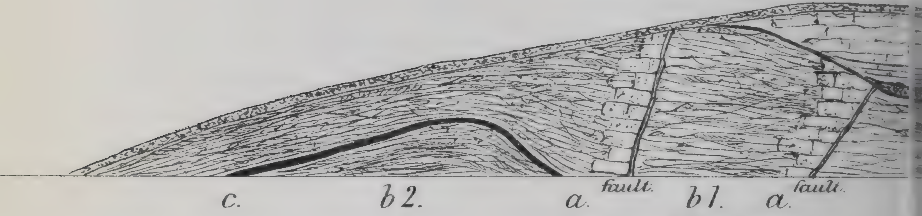
The junction of the Coal Measures and the Permian Limestone is exposed in the railway cutting near Upton Old Hall. The former consists of shales with beds of soft raggy sandstone which dip rapidly towards the S.W. They are a red or purplish colour. The Permian Limestone rests unconformably on the shales and extends almost horizontally towards the east.

The diagram (Pl. IV., Fig. 1) represents the section exhibiting the position of the two series of rocks. The Coal Measures are highly inclined and also considerably displaced, and broken by faults. The section is taken from the north side of the cutting; the greatest depth exposed is about 20 feet, and at that point a fault in the Coal Measures throws a raggy sandstone, *a*, against the shales, *b*, the latter nearly horizontal, the sandstone much broken and contorted. West of the sandstone a second mass of shales, *b* i, occur, and these are again thrown into juxtaposition with the sandstone, *a* i, by a second fault. The remaining portion of the cutting is in shales, forming an anticlinal, interstratified with them, there is a bed of coal, *c*, six inches in thickness. The Magnesian Limestone beds overlie those of the Coal Measures, extending a short distance to the west of the principal fault. At the base of the limestone is a bed of quicksand, *d*, about six feet in thickness, but thinning out towards the fault where it is only two feet thick. It is much current-bedded; and appears in all respects similar to the beds of quicksand at Garforth and other places. The lower six feet of the limestone is thin-bedded and somewhat slaty, above this it possesses the usual character of the lower limestone, being thick-bedded and massive, with numerous cavities lined with crystals of carbonate of lime.

Eastwards from the Upton section all the exposures are in the lower limestone until the tunnel is reached. The latter for a considerable distance from either end is quarried from the same limestone, but towards the centre of the tunnel coal measure shales are again met with. Beyond the tunnel the lower limestone dips rapidly eastwards, and above it a considerable thickness of the middle marls is exposed in the cuttings. Near the Pack Saddle Plantation, where an accomodation bridge crosses the cutting, the lower part is formed in the lower limestone, above which is about eight or ten feet of Red or Purple Marl. Between the two, in hollows on the surface of the limestone are small lenticular masses of unctuous yellow clay. (Pl. IV., Fig. 2).

Eastwards from the River Went, near Little Smeaton, the middle marls in turn disappear beneath the Upper Limestone. The junction of the two may be seen in the cutting about a 100 yards beyond the river, dipping rapidly eastwards. The marls are composed of a yellow sandy clay, with about four inches of

Fig. 1. Section at Upton in a Cutting



Coal Measures.

a. Sandstone.
b. b1. b2. Shales.
c. Coal.

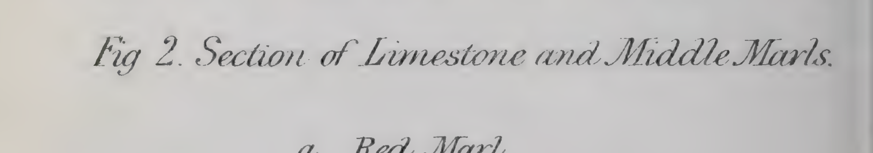
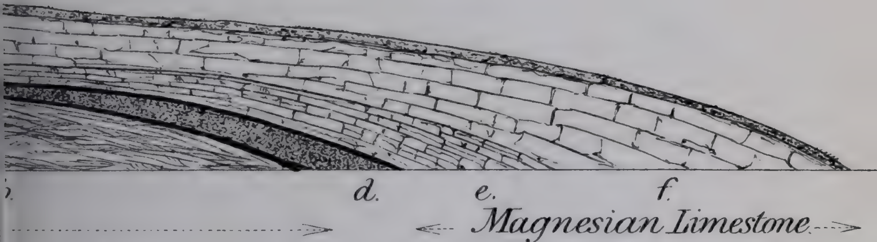


Fig 2. Section of Limestone and Middle Marls.

a. Red Marl.
b. Yellow Clay.
c. Lower Limestone.

he Hull and Barnsley Railway.



d. Quicksand.
e. f. Limestones.

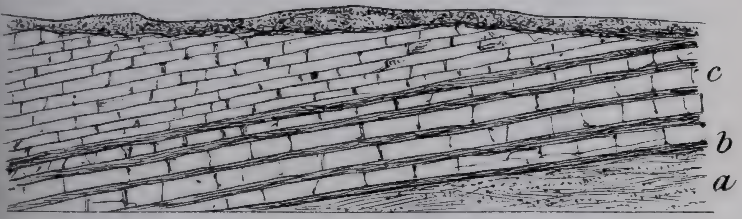


Fig. 3. Junction of Middle Marls & Upper Limestone.

a. Yellow Sandy Marl.
b. Blue Sandy Clay.
c. Thin Bedded Limestone with Marl Partings.

A. Megson & Sons. Litho. Leeds

a blue sandy clay. The limestone is thin-bedded with thin partings of clay or marl. (Pl. IV., Fig. 3).

NOTES ON THE EXCURSION TO THE WEST-RIDING OF YORKSHIRE: TOGETHER WITH PRELIMINARY REMARKS BY W. H. HUDLESTON, F.G.S., PRES. OF THE GEOLOGIST'S ASSOCIATION, LONDON.

The West Riding of Yorkshire exceeds in extent either Devonshire or Lincolnshire, yet in spite of its size the Carboniferous Rocks alone form a very large percentage of its area—a circumstance no doubt contributing largely to its wealth and importance. Thus, when people hear of the West-Riding, visions of smoke and steam, of factories, collieries, forges, and all the concomitants of a black country present themselves to the imagination. Yet the district visited on this occasion has none of these things, being purely agricultuaal or pastoral, mostly the latter; not densely inhabited, and constituting an agreeable tract of hill country which becomes mountainous towards the west. It forms part of a large block of older Carboniferous Rocks, which a series of east and west folds has brought to the surface between the Coal Fields of Durham and South Yorkshire, and is included within the wapontakes (hundreds) of CLARO and STAINCROSS, the latter being nearly coincident with the archdeaconry of *Craven.*

Claro commences where the first roots of the Penine chain spring out of the Vale of York. Hydrographically it comprises the whole of the basin of the Nidd, together with small portions of the Ure on the north, and of the Wharfe on the south. Harrogate, with nearly 10,000 inhabitants, is the largest town, but Knaresborough must be regarded as its historic capital. Excepting strips of Trias and Permian on the east, almost the whole of Claro is on Millstone Grit, in parts covered by Drift. The surface ranges from 100 feet to 2,200 feet above sea level, and contains a considerable proportion of indifferent land, some of which, however, forms the best grouse ground in the county. There are wide upland plateaux with valleys of moderate slope: the hills never attain to the dignity of a peak, the most salient features being crags of gritstone, such as Almias Cliff (Kinder Grit), Brimham Rocks (Third Grit), and the rocking stones on Roggan Moor so celebrated in the annals of shooting. The Millstone Grits of this district contain waters of remarkable purity, and the valley of the Washburn is now the storehouse for Leeds, just as Loch Katrine is for Glasgow.

On reaching the valley of the Wharfe at Bolton a different style of country begins to appear, though Bolton may be regarded as partaking of the Millstone Grit scenery of Claro, and of the Carboniferous Limestone scenery of Craven; where the hills are usually tabular, but with a peaked termination in places. The weathering of the Carboniferous Limestone produced long scaurs or cliffs, such as those at Malham, Gordale, and Kilnsea. The climate being wet and the soil calcareous, Craven is given over almost wholly to grass—some of the very best and most feeding pasturage in England. Skipton is the principal town, and has always been regarded as its capital.*

---

* It used to be said that a squirrel could go from Knaresborough Castle to Skipton Castle without once touching the ground. Those were the days when Knaresborough Forest used to be covered with "*silva minuta*," most of which has long since disappeared.

Knaresborough was about as far south as the marauding Scots ever got in their numerous forays into the North of England. During the dis-organization which succeeded the battle of Bannockburn their army ravaged the country up to the very gates of York, (A.D. 1319). The people of Ripon paid black-mail and were let off. The men of Knaresborough, a royal burgh, stood the risk of battle, and were defeated. Part of the inhabitants took to the church tower, where the Scots tried to burn them alive; the marks of the fire are said to be still visible. The Scots returned home by way of Skipton, which was also

We obtain our knowledge of the geology of the country round Harrogate chiefly from Mr. Fox Strangway's "Memoir," whilst the excellent work of Davis and Lees treats of the West Riding as a whole.

The PERMIAN rocks in the eastern part of Claro, though mostly unfossiliferous, are not without interest. The *Lower Marl* has a very slight development; but 5 feet of red and grey marls, belonging to this section, are to be seen in St. Helen's Quarry, south-east of Knaresborough. These are the marls to which allusion will presently be made in connection with the subject of rock staining.

The most important member of the series is the *Magnesian Limestone.* Only a few fossils have been found in this district, and those chiefly from the lower beds, though traces of *Axinus* may be seen in beds which are highly dolomitzed. At Knaresborough the yellow earthy variety is most frequent. It lends itself to the formation of caves, and, owing to its peculiarly friable structure, imparts a character to the gorges through which nearly all the

---

harried and burnt. The route between the two towns was so desolated that forest tenants were partly excused their rent to the King under the plea of impoverishment.

The more modern history of Knaresborough commences with the grant by Edward III. to John of Gaunt (A.D. 1371,) since which time the town and district may be said to have followed the fortunes of the duchy of Lancaster. About the same period Skipton was granted to Robert, Earl of Clifford, the ancestor of that ruthless partizan of the House of Lancaster, who slew the boy Earl of Rutland at the Battle of Wakefield.

We cannot doubt that, during the wars of the Roses, the district between Knaresborough and Skipton must have been strongly Lancastrian; and thus it came to pass that, when Henry VI. and Queen Margaret lay at York in the spring of 1461, an order was issued, in the name of the King, to summon all "liege men of the forest and demesne of Knaresburgh" to join the Lancastrian army. This was a few days before that fatal Palm Sunday which witnessed the complete triumph of the Yorkists at Towton on the banks of the Cock,

When the rivers ran all gory,
And in hillocks lay the dead;
And seven and thirty thousand
Fell from the white and red.

A battle wherein more Englishmen died than any other that has yet been fought.

rivers of the West Riding have to pass on their way into the Vale of York. Most of these earthy varieties contain probably about 25 per cent. of carbonate of magnesia; they are quite useless as building stones, but make excellent mortar. This porous, spongy sort of rock passes into yellow crystalline dolomite, frequently showing coloured bands; the more ferruginous varieties being studded with radiations of a metallic oxide, which is probably magnetite.* No purer form of dolomite than this would seem to occur in the Knaresborough district. But a few miles further south the crystalline dolomites of Huddleston Quarry are famous; there occurs also in Towton Field a form of Magnesian Limestone which is concretionary in small ovoids, almost resembling an oolite.

The *Middle Marl* succeeds the Magnesian Limestone, and in some cases must overlap it. This sub-division consists of red marls, and soft red sandstone, with some gypsum. Above it some small remains of the *Upper Limestone* are visable in a cutting to the west of Knaresborough.

The association of gypseous marls with beds of magnesian limestone is worthy of attention as having an important bearing on the origin of magnesian limestones, regarding which there are so many rival theories. Is the double carbonate a contemporaneous product, or the result of subsequent dolomitisation? Some are disposed to regard the formation of magnesian limestone as the

---

Sir William Plumpton, the commander of the Knaresborough contingent, was taken prisoner, and his son slain along with many others of less degree, so that days of mourning fell upon the manor and forest.

The bloody Lord of Skipton, Shakespeare notwithstanding, had fallen in a preliminary skirmish, but his youthful son, afterwards known as the Shepherd Earl, found refuge under the care of Sir Launcelot Threlkeld in the wilds of Saddleback, whence he emerged to resume his rank and estates on the final triumph of the House of Lancaster.

The part played by the royal castles of Knaresborough and Skipton, during the Parliamentary wars, is too well known to require further mention.

---

* These markings, on examination are seen not to be dendritic: still they may contain some oxide of mangnanese.

result of precipitation in an inland sea, or at any rate of deposits due to streams charged with carbonate of lime and sulphate of magnesia; when, as Sterry Hunt has endeavoured to show, dolomite and gypsum would be the products. Prof. Green thinks that the palæontological facts noted in the Magnesian Limestone of Yorkshire favour this view, and he gives a history of the sequence of events, beginning with sandy deposits (the quicksands at the base of the Permian in South Yorkshire), which pass into sandy dolomites, and thence into pure dolomite. The fossils occur mostly in the lower beds, and as the waters became more highly charged with saline matters, so life became scanty and dwarfed. He also looked to volcanic action as a source of supply for magnesian salts; but Mr. Lucas pointed out that the requisite materials might have been derived from the Yoredale Rocks and Millstone Grit of the neighbourhood, which were in all probability already above water. These questions have an additional interest as bearing on the probable position of the old shore line of the Permian sea in these parts, and on the date of the Pennine upheaval.

THE MILLSTONE GRIT Series is classified by Davis under the head of shore deposits with marine intercalations. The name serves to show the misleading character of a petrological title, as the group is full of shales, often containing ironstone, the smelting of which in former years has much to do with the disappearance of wood from Knaresborough Forest.

In the neighbourhood of Harrogate and Knaresborough the upper divisions of the Millstone Grit, including the "*Rough Rock*," are wanting, the highest beds now found belonging to the "*Third Grits.*" This circumstance is of course the result of pre-Permian denudation, which has not only removed the Coal Measures, but a considerable portion of the Millstone Grit likewise. Consequently, in this district, the Permians repose unconformably upon certain quartzo-felspathic grits, which are often of a red or purple colour. These are largely developed throughout many parts of the drainage area of the river Nidd, appearing in moderate elevations at Plompton, but rising to a height of nearly 1,000 feet above sea level in Brimham Rocks.

It is these Plompton Grits which the older geologists were disposed to regard as the equivalent of the "Rothliegende," apparently from a general impression that the base of the Permian should be *red*, in order to correspond with the beds in Germany. The Red Rock of Rotherham, now known to be a member of the Upper Coal Measures, was for a long time classed with the "Rothliegende," in deference probably to the opinions of Phillips and Sedgwick. It is hardly necessary to repeat that, throughout Yorkshire, the unconformity of the true Permian to all members of the Carboniferous is one of the most marked features in the stratigraphy of the country. This was recognized by Phillips, and yet he persisted in regarding the Plompton Grits as "Rothliegende." Mr. Binney seems to have been the first to suspect, from the character of the few fossil plants occasionally found in these beds, that they were not of Permian age, whilst later on, Mr. Clifton Ward and the Government Surveyors succeeded in establishing their true stratigraphical position as members of the Millstone Grit.

The coloration of these beds has also been the subject of much controversy. The causes which have produced rock-staining in the underlying beds, at the junction of the Permian and Carboniferous of these parts, may not be all of the same nature. Mr. Ward thought that the prevalence of a red colour in the underlying rock might be due to some action exerted by the Magnesian Limestone on the percolations; and this notion has attained a certain degree of acceptance, though it is difficult on chemical grounds to see exactly what the nature of such action can be. Moreover, it is quite an open question whether there really is any increase of red colour in the grits which lie beneath the Magnesian Limestone; indeed, that there is any such increase is denied by Mr. Lucas, who, as before mentioned, was inclined to attribute some of the red colouring to a lower marl now removed. In many parts of the Nidd valley the stratum of grit in actual conjunction with the Magnesian Limestone is often less highly coloured than the bed below. There can be very little doubt that much of the red colour of the Plompton Grits is due to the quantity of red felspar which they contain, so that possibly the principal causes were pre-existent within the rock itself.

The fossiliferous horizon known as the Cayton Gill beds, (*c* of the diagram, Fig. 1), is seen on both sides of the Harrogate anticlinal. *Productus semireticulatus* is the most abundant fossil; *Streptorhynchus crenistria* is fairly plentiful, as also a very pretty *Fenestella*; the joints of Encrinites are very abundant.

Kinder-Grits.—The base of the Millstone Grits consists of three thick grit beds associated with still thicker shales. Some of these grits have been extensively used for building stone at Harrogate, but they are very porous. Though usally pretty free from strong colours, these beds are occasionally very purple, though exposure soon removes the tint. The outliers of the Millstone Grit Series in Craven mostly belong to this section.

YOREDALE ROCKS.—This is a group established by Phillips for a variable series of beds between the Carboniferous or Scar Limestone of Craven, and the Millstone Grit. It is well devoloped in Craven and throughout the west, consisting of shales, limestones, and peculiar grits, often calciferous. In the bed of Hodder, Yoredale Shales, with their limestones and layers of ironstone, give rise to springs containing sulphuretted hydrogen. In Bolland Forest these shales are dark and full of molluscan and fish remains. Near Skipton the Yoredale Rocks consist of calcareous shales and limestones with many fossils, the beds sometimes being of a ferruginous and bituminous character; sulphur springs occur there in a position somewhat analogous to those at Harrogate. The altitude of the Yoredale Rocks at the latter place may be gathered from the diagram, Pl. IV, Fig. 1. Very little is known about the shales of this group, but the Harrogate roadstone (*a* of the diagram) is a remarkable rock; below this are other shales and another peculiar grit.

The Yoredale Grits at Harrogate are so peculiar that, being in some way connected also with the phenomena of the sulphur springs, a brief description may be useful before proceeding to consider the subject of the waters themselves. A large hand specimen from the Beckwithshaw quarry shows three different phases. Firstly, a fine-grained quartzo-felspathic grit without lime; secondly, a calciferous encrinital grit, where the lime has mostly been removed, but where the structure of the crinoidal stem is better brought out in consequence; thirdly a more calcareous portion. A hand specimen from the bottom of the sulphur well on Harlow Carr is a very fine-grained quartzo-felspathic grit with much white mica, and coaly matter in bands and blotches. In the Low Harrogate quarry (Cold Bath Road), the crinoidal character is very prevalent, and where the soluble matter has been removed, it becomes a spongy, silicious, encrinital grit. The decomposition of this rock produces a good soil, but we may well believe that the surface beds have already parted with some of their constituents, and the iron-stained nature of the joint faces points in the same direction; it is in the stuff formed in these cracks that the little double-pyramid quartz crystals, known as Harrogate diamonds, have been deposited.

The Harrogate waters,* both sulphur and iron, occur in connection with a triangular patch of Yoredale rocks, of which a cross section is seen in Pl. IV., Fig. 1. This patch is bounded towards the N.W. by the main fault, and extends for about three miles S.W. of Harrogate. There are about 80 springs in all. The strongest waters rise in the little valley of Low Harrogate between the Bog Field, 375 feet, and the Montpelier Spa, 335 feet. This is the nucleus of the sulphur waters; the strong iron waters are near, but usually occupy an outer area. It is evident that an iron water and a sulphur water are incompatable, yet they wait closely on each other, and must in some way be connected. One of the great puzzles is to understand how they are kept apart in the ducts which convey them to the surface. The very high angle of the beds, and the peculiar jointing of the encrinital grit probably have something to do with it.

---

* For further details consult "The Harrogate Waters," by George Oliver, M.D.—H. K. Lewis, London.

The composition of the Harrogate waters has often been studied from a therapeutical point of view, but it has also its geological aspect, and recent observations have brought out some features of considerable importance in this direction. Henceforth there will be less difficulty in understanding the vein deposits of the Carboniferous Series, as here we have an opportunity of testing the vital fluids of the rocks, as it were, in the act of circulation. An inspection of the accompanying table may serve to illustrate this.

The five waters, whose analysis is there given, are representative of the chief varieties. Technically the *Sulphur waters* are divided into strong saline, mild saline, and pure, the latter term being merely relative. It may also be noted that No. 3, selected as a type of the "pure sulphur," is situated at some distance from the triangular patch of Yoredale Rocks previously mentioned, and very near the junction of the Millstone Grit Shales with the Middle Permian Marls. At the same time it is not improbable that this spring may represent an overflow (from a spring) at Bilton, which is more in the direction of a slight prolongation of the anticlinal axis. In consequence of the absence in this water of the chlorides of the alkaline earths, there is a fair amount of alkaline carbonates, and the same is the case with the spring at Harlow Carr on the other side of Low Harrogate. In fact the further away from Low Harrogate the less amount of chloride occurs in the sulphur springs.

The Old Sulphur Well yields a pretty uniform supply, amounting to about 12 gallons per hour, though in the very dry year, 1868, there was some mention made of a threatened deficiency. The temperature is evidently pretty nearly that of the air, so that no appreciable amount of extraneous heat can be detected. Indeed, it may be said that all the waters of Harrogate are "cold," and, with one exception (the Alum Well), they have all a markedly alkaline reaction. Roughly calculating the Old Sulphur Well would yield seven tons of chlorides per annum, including 100 lbs. of Barium Chloride,* and 37 lbs. of Magnesium Bromide, with some Iodide. It would also produce 240 lbs. of Sodium Hydrosulphide (NaHS.)

The origin or source of these abundant impregnations has naturally been a matter of considerable difficulty. The most probable explanation is that the springs, though not superficial, are far from being deep-seated, and that the water supply comes mostly from the Harlow Hill district, which attains 600 feet elevation, and attracts a rainfall that cannot well average less than 35 inches annually. That the supply is not superficial may be inferred from the fact that the drainage from the Bog Field had no effect on the delivery of the waters, and thus the notion, held by Phillips, as to the bog origin of the sulphur waters would seem to be untenable. The large quantity of chlorides look very much as if a portion of the water of the sea or of an estuary† had been evaporated and the salts incorporated with the Yoredale Rocks during their formation. There is abundant evidence, both in this neighbourhood and elsewhere, of the quantity of organic matter,

---

* Barium Chloride was not noticed by Hoffmann, in 1854; and that chemist only found traces of Bromides and Iodides. Improvements in methods of analysis may account for the difference.

† The total Solids of the Mediterranean compared with those of the Baltic, present the following per centage differences. (Bischof, Vol. 1.)

	Mediterranean.	Baltic.
Solids	3·77	1·77
Haloids	$89\frac{1}{2}$	$94\frac{1}{2}$
Sulphates	$10\frac{2}{5}$	5
Carbonates	$\frac{3}{5}$	$\frac{1}{2}$
	$4·77\frac{1}{2}$	2·77

HARROGATE WATERS.—ANALYSES.

No. 1.—OLD SULPHUR WELL (Strong saline SULPHUR). Thorpe, 1875.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride	893·7	Total haloids...	105·5
KCl. 9·6, LiCl. 0·7, NH_4 Cl 1·0, $CaCl_2$ 43·5, $BaCl_2$ 6·6, $MgCl_2$48	109·4		
Magnesium Iodide	0·1		
,, Bromide	2·3		
Calcium carbonate	29·3	Total earthy carbonates	35·8
Magnesium carbonate	6·0		
Alcaline carbonates			nil.
Barium sulphate			0·5
Silica			3·7
Total solids			874·6

Gases.—Principally carbonic acid, in moderate amount with oxygen and nitrogen.

No.5.—ST. JOHN'S WELL (Pure CHALYBEATE). Hofmann, 1854.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride	1·5	Total haloids	1·5
Iodides	traces.		
Calcium carbonate	2·3	Total carbonates Ca. Mg. Fe	5·9
Magnesium carbonate	3·0		
FERROUS carbonate	0·6		
Sodium carbonate...	1·3	Total alkaline carbonates	2·3
Potassium carbonate	1·0		
Calcium sulphate			0·3
Silica			tr.
Organic matter			tr.
Total solids			10·0

Gases.—Principally carbonic acid, with some nitrogen, and traces of carburetted hydrogen and of oxygen.

temperature is evidently pretty nearly that of the air, so that no appreciable amount of extraneous heat can be detected. Indeed, it may be said that all the waters of Harrogate are "cold," and, with one exception (the Alum Well), they have all a markedly alkaline reaction. Roughly calculating the Old Sulphur Well would yield seven tons of chlorides per annum, including 100 lbs. of Barium Chloride,* and 37 lbs. of Magnesium Bromide, with some Iodide. It would also produce 240 lbs. of Sodium Hydrosulphide ($NaHS$.)

The origin or source of these abundant impregnations has naturally been a matter of considerable difficulty. The most probable explanation is that the springs, though not superficial, are far from being deep-seated, and that the water supply comes mostly from the Harlow Hill district, which attains 600 feet elevation, and attracts a rainfall that cannot well average less than 35 inches annually. That the supply is not superficial may be inferred from the fact that the drainage from the Bog Field had no effect on the delivery of the waters, and thus the notion, held by Phillips, as to the bog origin of the sulphur waters would seem to be untenable. The large quantity of chlorides look very much as if a portion of the water of the sea or of an estuary† had been evaporated and the salts incorporated with the Yoredale Rocks during their formation. There is abundant evidence, both in this neighbourhood and elsewhere, of the quantity of organic matter,

---

* Barium Chloride was not noticed by Hoffmann. in 1854; and that chemist only found traces of Bromides and Iodides. Improvements in methods of analysis may account for the difference.

† The total Solids of the Mediterranean compared with those of the Baltic, present the following per centage differences. (Bischof, Vol. 1.)

	MEDITERRANEAN.	BALTIC.
Solids	3·77	1·77
Haloids	$89\frac{1}{2}$	$94\frac{1}{2}$
Sulphates	$10\frac{2}{5}$	5
Carbonates	$\frac{3}{5}$	$\frac{1}{2}$
	$4{\cdot}77\frac{1}{2}$	2·77

HARROGATE WATERS.—ANALYSES.

No. 1.—OLD SULPHUR WELL (Strong saline SULPHUR). Thorpe, 1875.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride ...	893·7		
KCl. 9·6, LiCl. 0·7, NH_4 Cl 1·0, $CaCl_2$ 43·5, $BaCl_2$ 6·6, $MgCl_2$48 ...	109·4	Total haloids...	105·5
Magnesium Iodide	0·1		
,, Bromide	2·3		
Calcium carbonate	29·8	Total earthy carbonates	35·8
Magnesium carbonate	6·0		
Alcaline carbonates			nil.
Sulphates			nil.
Silica			0·7
SODIUM HYDROSULPHATE (NaHS) ...			5·2
Fe, SP_2 O_5, Al_2 O_3 and organic matter			traces.
Total solids . .			1407·2

GASES.

NOTE.—The amount of free H_2S found by Thorpe dissolved in water is given at an amount 3·7 grains per gallon. In his paper in the "Journal of the Chemical Society" no other gases are mentioned. Hoffman in 1854 found carbonic acid 22 cubic inches, carburetted hydrogen 6 cubic inches, nitrogen 3 cubic inches. He also states that the bubbles rising from these waters spontaneously consist mainly of carburetted hydrogen and nitrogen.

Temperature.—In 1872 this was found to range between 46°F and 52°F.

No 2.—"MAGNESIA" WELL (Mild saline SULPHUR). Musspratt, 1867.

Hospital Mild Sulphur.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride ...	215·	Total haloids...	245·9
KCl. 27·9, $BaCl_2$ 1·2, Mg Cl_2 1·8	30·9		
Iodides, &c.	traces		
Calcium Carbonate	18·3	Total earthy carbonates	31·3
Magnesium Carbonate	13·0		
Alcaline carbonates			nil.
Sulphates			nil.
Silica ...			1·6
SODIUM HYDROSULPHIDE (Na HS) ...			1·6
Si. Fe. Mn.			traces.
Total solids			280·4

GASES.

NOTE.—There seems to have been no separate estimation of the gaseous and alkaline sulphides. A moderate amount of carbonic acid was found together with some carburetted hydrogen, nitrogen, and a little oxygen.

No. 3.—STARBECK SPA WATER (PURE SULPHUR). Fairley, 1879.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride ...	116·4	Total haloids	116·4
LiCl, $BaCl_2$ ...	traces.		
Calcium carbonate	10·0	Total earthy carbonates	13·5
Magnesium carbonate	3·5		
*Sodium carbonate	14·5	Total alkaline carbonates	15·1
*Potassium carbonate	0·6		
Calcium sulphate ...			1·9
Silica ...			3·2
SODIUM HYDROSULPHIDE (Na HS) ...			1·4
Total solids . .			151·5

* According to Hoffman's analysis in 1854 the proportion of Na_2 CO_3 to K_2 CO_3 is nearly reversed. *Gases* not estimated.

No.4—"KISSENGEN" WATER (Strong saline CHALYBEATE). Attfield, 1879.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride ...	674·5	Total haloids...	850·7
KCl 21·5, LiCl tr, NH_4 Cl 0·4, $CaCl_2$ 87, $SrCl_2$ 0·8, $MgCl_2$ 65·5	178·8		
Iodides, &c.	traces.		
Calcium carbonate	9·0	Total carbonates of Ca. Mg. Fe	20·7
Barium carbonate	2·1		
FERROUS carbonate	9·6		
Alkaline carbonates			nil
Barium sulphate ...			0·5
Silica ...			3·7
Total solids ...			874·6

Gases.—Principally carbonic acid, in moderate amount with oxygen and nitrogen.

No.5.—ST. JOHN'S WELL (Pure CHALYBEATE). Hofmann, 1854.

	GRAINS IN GALL.		GRAINS IN GALL.
Sodium chloride ...	1·5	Total haloids	1·5
Iodides	traces.		
Calcium carbonate	2·3	Total carbonates Ca. Mg. Fe	5·9
Magnesium carbonate	3·0		
FERROUS carbonate	0·6		
Sodium carbonate...	1·3	Total alkaline carbonates	2·3
Potassium carbonate	1·0		
Calcium sulphate ..			0·3
Silica ...			tr.
Organic matter ...			tr.
Total solids ...			10·0

Gases.—Principally carbonic acid, with some nitrogen, and traces of carburetted hydrogen and of oxygen.

chiefly of vegetable origin, locked up in the Yoredale Rocks. Hence it is not unreasonable to believe that the putrefactive distillation of such organic matter, acting very slowly and through long periods of time, effects more or less the complete deoxidization of the sulphates, and that to this we owe the quantity of sulphide present in the Harrogate waters. The considerable quantity of carburetted hydrogen and of nitrogen found by Hoffmann favour this view, which is much strengthened by the almost complete absence of oxygen, showing that the nitrogen present is due to organic decomposition. At the same time the very slight traces of phosphoric acid would show that this mainly arises from vegetable matter.

EXCURSION ON THE 17TH JULY, AND FIVE FOLLOWING DAYS.

Directors:—W. H. HUDLESTON, F.G.S., ETC., *President of the Geologists' Association, London;* AND JAMES W. DAVIS, F.G.S., ETC., *Honorary Secretary of the Yorkshire Geological and Polytechnic Society.*

The London contingent arrived at Harrogate on Monday afternoon, and having secured quarters at the Prospect Hotel, re-assembled with the other members of the party at the Old Sulphur Well. Here they tested the quality of the water for which the place is celebrated, and availed themselves of the permission which was given to them to descend underneath the floor of the building to inspect the springs which supply the pump-room above. The President of the Geological Association, London, who on this occasion was the director, offered a few remarks on the chemical composition of the water and of several other sulphur waters of Harrogate. He was enabled to illustrate his observations by means of a number of specimen tubes containing the saline contents of one gallon of each of the various waters to be found in the town, and by this method the different volumes were at once perceived. These very interesting tubes had been prepared from evaporations conducted by Mr. Davis, chemist, of Harrogate. They are the property of theHarrogate Improvement Commissioners, who kindly lent them for the occasion. Mr. W. H. Wyles (the Clerk to the Commissioners), and Mr. W. W. Harry (the engineer), afforded the party every facility in the examination of the specimens. Whilst the company were thus engaged, Dr Oliver, who is well known as the author of a valuable work on "Harrogate Waters," appeared at the wells and supplemented the President's observations. Dr. Oliver dwelt more especially upon the geological conditions under which the water finds it way to the surface in connection with the very remarkable anticlinal which is known to exist at Low Harrogate. The singular stratigraphy of Harrogate arrested the attention of geologists a long time ago. Mr. Wm. Smith, the father of English geology, was the first to appreciate the peculiarity, but although he recognized that there was an anticlinal or upthrust of lower rocks, extending from Harlow Hill to Lower Harrogate, he appears to have thought that within that anticlinal there was a synclinal basin towards which the springs gravitated. Later on, his nephew, the late Professor Phillips, who for forty years had given great consideration to the peculiarities of the geology of Harrogate, drew the attention of the Geological Society of London to the very remarkable features of the district, the difficulties in regard to which had been to some extent cleared up during the making of the new railway across the stray. The subject of the anticlinal was treated generally in a diagram in the paper brought before the Geological Society by Professor Phillips, and the relation of the millstone grit beds to the north and south of the Yoredale rocks beneath was made very clear. At the same time Professor Phillips seems to have had a notion that there was a sort of synclinal towards the apex of the anticlinal, and his section at this part of the diagram is somewhat obscure and difficult to comprehend.

When the party left the Old Sulphur Wells they proceeded to verify the stratigraphical facts in connection with the anticlinal, and for this purpose walked to the well-known road-stone quarry in the Cold Bath Road. This stone is one of the hard beds of the Yoredale rocks, and is a calciferous grit very largely charged with the remains of encrinites. In the Cold Bath Road quarries these rocks may be seen dipping at a considerable angle in a south easterly direction. In the bed of the stream, just at the back of the old sulphur well, the same rock is observed to dip in a direction somewhat to the north of east, and a little further up the hill, underneath Cornwall house, this same bed dips at a very high angle indeed, nearly due north. These facts are taken to indicate that there exists an anticlinal dome, which is here seen to be dying out to the eastward, and the north side of the anticlinal is very much steeper than the south—in fact, the anticlinal itself is fractured a little on the north-west side of what may be presumed to be its principal axis by a great fault which causes the road-stone to be brought into juxtaposition with the lower beds of the millstone grit. There are geologists at Harrogate who consider that the axis of this swelling or anticlinal is to be found beneath the Stray rather than at the sulphur springs, and this view receives some substantiation from the appearances which were noted when the railway was made across the Stray. The probable explanation is, that the Harrogate road-stone and its accompanying shales are bent into more than one series of curves, and that one of these curves very nearly reaches the surface in the railway cutting. A northerly dip of the beds near the Low Harrogate Church is further evidence of the probability of this view. The party having satisfied themselves as to the reality of the anticlinal axis, were conducted to the Bog Springs, where there are something like 34 different sources of sulphur and iron waters. Dr. Oliver here indicated the peculiarities of the position and nature of the several waters, and deduced from his observations the fact that as a rule the sulphur springs occupy an inner position, and that the iron springs are without, on either side of the main axis or upheaval. The nature of the several wells was pointed out, and attention was especially drawn to the very abnormal water known as the "Alum Well." It may be mentioned that one of the characteristics of the sulphur waters at Harrogate is the absence, more or less complete, of sulphates. This peculiarity enables many of the Harrogate waters to act as carriers of salts of barium and strontium, which would otherwise be insoluble. In the "Alum Well," however, a large quantity of sulphates exist. The probability is that this is due to the shallow origin of the spring, whose waters become oxidised, and this may account for the very considerable quantity of sulphates and the acid reaction so exceptional to the waters of this neighbourhood. Having spent some time at the springs, the company walked to Birk Crag, where they had an opportunity of looking from that very picturesque ridge of millstone grit over the wild and dreary scenery of Haverah Park, which consists entirely of the grits and shales of the millstone grit group. These rocks are noted for the purity of their waters. Oak Beck, which flows through Haverah Park, has been utilised for the purpose of supplying the town of Harrogate with pure water, just as the Washburn River has been adapted for supplying Leeds. The remainder of the evening was spent by the party in walking round by Harlow Carr and the back of Harlow Hill to Harrogate. They afterwards met at the Prospect Hotel and were very kindly welcomed to Harrogate by M. Richard Carter, F.G.S., of Spring Bank, Harrogate, who, with Mr. Harry and other gentlemen, had done much to facilitate the success of the excursion.

On Tuesday, the party left Harrogate for Knaresborough by an early train, and after a brief inspection of the old castle at the latter place, descended to the foot of the cliff on which what is left of the ancient pile stands. Here the unconformable junction of the magnesian limestone upon the millstone grit was pointed out by the president of the association and verified by the members. From this point they crossed the river for the purpose of visiting the Dropping Well, which is too well known to need description. Mr. Hudleston took occasion to explain the nature of the waters which flow over the rock. The stream supplying these waters springs out of the adjacent cliff, and represents the drainage of a hollow originating in the high ground towards Belmont. The ground is chiefly made up of the Middle Permian Marls, and it is to the salts in these marls that we must trace the impregnation of the Dropping Well Waters.

The following is an old analysis of the waters of the stream:—

	Grains to the gallon.
Carbonate of soda	6
Carbonate of lime	23
Sulphate of lime	132
Sulphate of Magnesia	11
Total	172

The deposit upon the sponges and other substances which are placed at the well, consist almost wholly of carbonate of lime, the amount of sulphate of lime deposited being very small indeed, notwithstanding the very large quantity found in the water. Mr. Simpson, the lessee of Long Walk and the "Mother Shipton Inn," recently possessed himself of some magnificent specimens of sponges, which, from their porous nature, show the action of the deposit remarkably well. Some time was spent by the party in examining the caves in the valley of the Nidd, and in listening to the stories of St. Robert and of Eugene Aram, after which they crossed the river at Grimbald Bridge and finally took leave of the magnesian limestone where the romantic Grimbald Crag is terminated by a small fault on its western side. Plumpton Rocks, a mile and a half distant, were next visited. These rocks are interesting to geologists as having been regarded in former days as forming a portion of the Permian series, equivalent to the German "Rothliegende." The researches of the Government surveyors in recent years have shown that these rocks are really nothing more than the highest beds in this district of the millstone grit series, which are unconformably overlaid, as already noted in the Nidd Valley by the Permian Rocks. The extraordinary action of the weather upon these rocks afforded matter for endless speculation. In this respect the Plumpton Rocks, which are the same bed of grit which forms the Brimham Rocks at a higher level, are possibly more singular and grotesque in their weathering, than even the Brimham Rocks themselves. The party now divided, some returning to Harrogate in carriages, the others walking along the road. In the afternoon they were joined by Mr. J. W. Davis, and about a dozen of the most enthusiastic members of the party, including that gentleman and the president, drove to inspect the new quarry of Harrogate road-stone at Beckwithshaw. A small spring of sulphur water has recently been discovered near there by Dr. Oliver. In the evening, Mr. Hudleston congratulated the members on the arrival of Mr. Davis, and placed the direction of the excursions for the remainder of the week in his hands.

Wednesday was an important day for the excursionists, as they had to transfer themselves in conveyances from the base of operations at Harrogate to Skipton, *via* Knaresborough Forest and Bolton. The early part of the journey was sufficiently dreary, the scenery of this portion of Knaresborough Forest being somewhat tame and uninteristing. A number of fossils were discovered amongst the stone heaps on the roadside near the Little Wonder Inn, these coming from the well-known quarries in the millstone grit series, near Hampsthwaite. The excessive rarity of fossils in the millstone grit makes their occurrence in this bed of considerable interest. They appear to differ but slightly from species known to exist in the carboniferous limestone. Having safely passed the "dangerous corner" the director and his followers descended into the valley of the Washburn, where the extraordinary size of the artificial lakes provided for the Leeds water supply struck everyone with astonishment. The Pass of Kexgill, the next object of interest on the route, presents evidence of the anticlinical axis in the way in which the grit rocks dip on either side. Having reached the summit of this pass, the party drove rapidly down the descent to Bolton Bridge, and at about half-past twelve arrived at the Devonshire Arms, where a substantial lunch, for which the excursionists were well prepared, was served.

About four hours were devoted to Bolton Abbey and the Strid, where many of the gentlemen from the south for the first time saw one of the most beautiful and interesting spots in Yorkshire; indeed, so fascinated were they with the charms of this delightful valley, that it was rather late when the journey was resumed. It may be stated that the Strid is cut through what is known as the Kinderscout grit, being the lowest grit of the millstone series. Opposite Bolton Abbey there is a very fine section in the Yoredale shales, showing both faults and contortions. This is on the north side of the anticlinical. The stratigraphical phenomena between Bolton and Skipton are of the most marvellous kind. The long system of disturbances extending from the neighbourhood of Clitheroe to Harrogate, here assumes a most striking phase, and the quarries exhibit some extraordinary sections in consequence. The first quarries visited are known as the Hambleton Rock Quarries, where the Skipton rock, supposed to be mountain limestone, has been forced into a vertical position, and is variously contorted. Continuing the drive towards Skipton, the party made a diversion in the direction of Draughton Quarry, an excavation in the Yordale rocks, where some remarkable phenomena of rock curvature may be seen to great advantage. Some of the choicest of these have been photographed by the Yorkshire Society, and form beautiful pictures, apart from their supreme geological interest. The excursionists had some difficulty in finding their carriages again. Skipton was not reached until a late hour in the evening, and it was some time before the party were settled in their various quarters, but, thanks to the admirable arrangements made by the Honorary Secretary, everything was finally put to rights.

By an early train on Thursday morning the members of the Societies travelled from Skipton to Bell Busk, and most of them walked from thence to Malham, a distance of nearly five miles. The hillocky character of the ground, due to the glacial deposits was noticed. Malham Cove is situated on the line of the south Craven fault. (See diagram.) The director having arrived at the foot of that remarkable cliff, just where the river Aire springs from the base of the precipice, drew attention to the geological characteristics of the scene, more especially in connection with the underground course of the water which disappears a little to the south of Malham Tarn. The party retraced their steps in the direction of the village of Malham, and then walked to Gordale Scar, some of the gentlemen visiting Janet's Cave on the way. The gorge at Gordale is an excavation in what is known as the Scar Limestone, which is the lowest member of the carboniferous series in this district. The visitors were scarcely prepared for such an impressive scene, and nearly all agreed that it is one of the most remarkable spots, not only in Yorkshire, but in England, and that probably no part of the carboniferous limestone, not even excepting the celebrated Cheddar Cliffs, can compete with Gordale in wonder and magnificence. The stream which flows through this extraordinary gorge, by its numerous waterfalls, adds largely to the interest of the scene. There can be very little doubt that this excavation is almost entirely the result of water action, aided to a certain extent by rock-jointing in the first instance. The scramble up the gorge is a somewhat difficult undertaking, but was safely accomplished, and the whole of the party finally stood on the limestone pavement of the moors above. From thence a rather rough walk led them to within a short distance of Malham Tarn, which is said to be situated on Silurian rocks and boulder clay. At the place where the water sinks, to reappear, as already stated, at the foot of Malham Cove, the director read the following interesting communication from Mr. Walter Morrison with reference to the underground course of the water, which disappears at this point.

"MALHAM TARN, BELLBUSK, JULY, 10TH, 1882.

"DEAR SIR,

"Very unfortunately I have to leave home on Wednesday, July 19th, for a Board Meeting in London on the Thursday, and a Meeting of a Company of which I am a director, on the Friday.

It will thus be impossible for me to join you; but I assure you in all honesty, that I regret it very much; as an amateur geologist learns a great deal from accompanying experts in the field.

"The following notes may be of interest when you come into this parish, and may be new to you. Two years ago the Bradford Philosophical Institute came here to ascertain what becomes of the water of Malham Tarn after it disappears at the water-sinks south of the Tarn, The plan adopted was as follows: on the previous day I opened the sluice at the foot of the Tarn, and so lowered the water a foot below its normal level. Thus the beck running out of the Tarn became very low, almost dry, when we closed the sluice again, only allowing a mere trickle of water to run along the beck to keep the beck trout alive. On the next day we all compared watches, and then parties were placed to watch at the spring under Malham Cove and at Aire Head, the very strong spring which you will find marked on the one inch Ordnance Map, some 300 yards north-east of the farm house, called Kirkby Top, which is 800 yards south of Malham. Marks were placed in the water at each place. At 1 p.m. exactly, I let the tarn water out by the sluice, and it ran in a muddy stream, and with a rush down the beck to the water-sinks. The water-sinks were reached in 20 minutes; and in 65 minutes from then the water began to rise at Aire Head; in 5 minutes more the Aire Head was boiling up with a very turbid stream. The water at Malham Cove began to rise at 110 minutes from the time when the released tarn water reached the water-sinks, but did not rise much, nor was it turbid, so I infer that both Aire Head and Cove Springs are connected with the water sinks, but that a lower channel of a certain capacity communicates with Aire Head and another passage branching from it with the cove spring, which latter receives the tarn water when the Aire Head passage has become filled. The cove water in normal times probably comes from a water-sink in a pasture called Streets, south-west of the Tarn, but we have not been able to prove this.

"In walking from Malham the best foot road is by Well Head Lathe; it is shorter and prettier. By the carriage road observe at Carlton the conspicuous white farm house; this is on the site of the house of General Lambert. The church is interesting, observe the Saxon or Norman Font, the niches for saints in the pillars, said to be a characteristic of churches built by the Tempest family; also the Lambert Monuments.

"On Malham Moor the Silurian Rock crops out at the point where the road to Kilnsey crosses the beck above Gordale; in the line of springs between Waterhouses Caponer: in the bed of the beck in Streets Pasture; in the Grip by the side of the road near Caponer; on Black Hill, Catrigg Pasture, Neals Ing, and then at Horton.

"Two stones in the Tarn near to, and north of the great Close Plantation, are a conglomerate of fragments of slate mixed and cemented with lime. They just show above water. Bye the bye, will your party want my boats? I have three. Will any of them care to fish? If so write to me and I will tell my keepers.

"Believe me, yours very faithfully,

"W. MORRISON."

"James W. Davis.

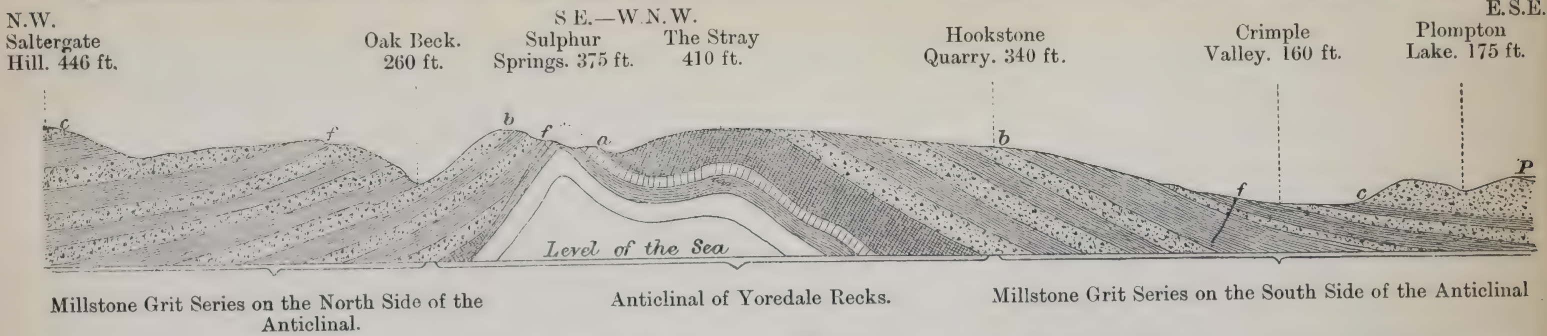
The opinion was expressed that the water at once falls into the north branch of the Craven fault, which crosses the moors about this spot. The kindness of Mr. Morrison in offering the party the use of boats and other facilities was duly acknowledged, and the Honorary Secretary was requested to convey the thanks of the Societies to that gentleman. Here the party divided. A number of them returned towards Malham, and thence to Bell Busk, and the other portion, under the guidance of Mr. Davis, took the road across the moors for the Victoria Cave and Settle. Owing to the inequalities of the ground, the latter party became sub-divided, though both sections arrived at the Victoria Cave about the same time. Some interesting observations relative to the position of the great north fault were made by some of the gentlemen present. The party finally descended into Settle by a very precipitous route. After a hurried visit to the museum at Giggleswick, where many of the objects found in the Victoria Cave are arranged, including the largest specimen of the grizzly bear which was ever found, the excursionists got to Settle Station just in time to catch the train for Skipton.

The weather, which had hitherto favoured the geologists in a most remarkable manner, changed for the first time during the week on Friday morning, when in a heavy shower the party proceeded from Skipton to Clapham. On arriving at the latter place, the clouds broke, and it was comparatively fine for a few hours. This enabled your secretary to take his trusty followers through the grounds belonging to Mr. Farrer, where the effects of one of the great faults are very well shown in the gorge of the stream. A section of the party then visited the well-known Clapham Caves, whilst a smaller number proceeded up Trou Gill to Gaping Ghyll Hole. It is very well-known that the waters which are collected on the southern flanks of Ingleborough and which flow as an ordinary beck down to this point, suddenly disappear in the yawning limestone just as one might imagine a river turned into a pit shaft. The waters are doubtless those which re-appear close to the Clapham Cave. At some time or other the course of this stream was on the surface, and the lines of the old valley are still to be seen, though the stream no longer excavates that portion of the valley between Gaping Ghyll Hole and the place of its final emergence into daylight near the Clapham Caves. It may be as well here to draw attention to the readiness with which water sinks in these limestone districts, —a circumstance due partly to the jointing of the rocks themselves and partly to their solubility in carbonated waters. Both branches of the party ultimately returned to Clapham, where they re-assembled at lunch, which was liberally provided by the landlord of the New Inn. Before leaving the table, Mr. Hudleston, the President of the Geologists' Association, took the opportunity of tendering the thanks of the Association to Mr. Davis for the admirable manner in which he had conducted the excursions. He spoke of that gentleman's extensive knowledge of the geological features of the district, and referred to the trouble which he had taken in making the arrangements which had given so much satisfaction to the visitors.—Mr. Davis made a suitable reply, in the course of which he expressed his gratification at having made the acquaintance of so many gentlemen, and hoped the present was only the first of a series of similar excursions. The rain was now coming down in torrents, and under these depressing circumstances very few of the members or their friends showed any anxiety to carry out the programme to its final completion. Only ten were found bold enough to enter upon the undertaking, amongst these being the Cicerone and the President. These gentlemen, well armed with umbrellas and waterproofs, walked, in a pouring rain which did not cease for a moment during the excursion, first of all to Norber, a distance of over a mile, where they saw the magnificent display of ice-borne boulders of Silurian rocks resting on mountain limestone. By Wharfe the small party walked round Moughton Fells to Foredale. At Combe Quarries they saw from below an almost classical section where the mountain limestone lies unconformably on the upturned and folded edges of the sulurian slates and grits. A hurried walk took them to Horton-in-Ribblesdale, where they had the good fortune to catch the 6.43 train to Skipton.

The contemplated excursion to Raygill Quarries on Saturday was abandoned, partly in consequence of the threatening nature of the weather, and partly because many of the members were anxious to return to their homes in good time.

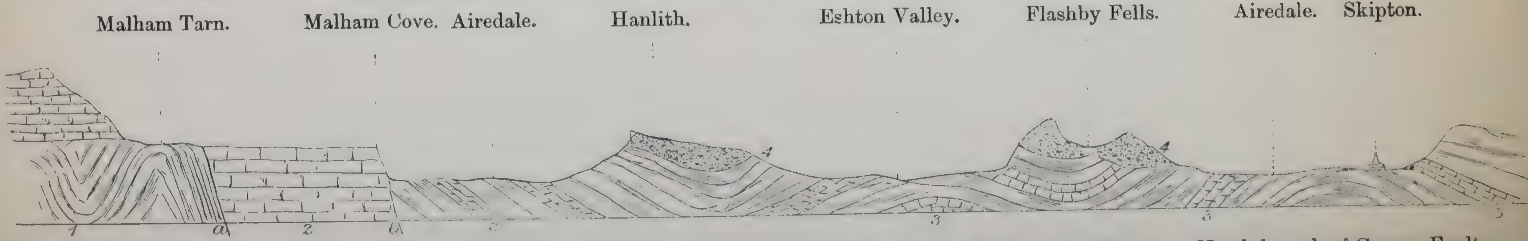
The excursions gave great satisfaction to the visitors, and were the means of introducing many persons for the first time to a district remarkable alike for its geological features and its fine scenery. There were few opportunities for obtaining fossils, but

DIAGRAMMATIC SECTION THROUGH THE HARROGATE ANTICLINAL. (Saltergate Hill to Plompton Rocks, a little under six miles.)



Explanation of Signs.—a. Harrogate roadstone. On the north side of the anticlinal this is forced against the principal fault *(f)*. *b.* The Uppermost Kinder Grit. *c.* Approximate position of the fossiliferous band (Cayton Gill Beds) in the Millstone Grit on either side of the anticlinal. *P.* Permian Beds (Magnesian Limestone.)

DIAGRAMMATIC SECTION FROM MALHAM TO SKIPTON- Distance 12 miles.



Explanation of Sign—1. SILURIAN GRITS. 2. MOUNTAIN LIMESTONE. 3. YOREDALE SERIES. 4. MILLSTONE GRIT. *a.* North branch of Craven Fault; *b.* South Branch.

some of the younger and more active members of the party applied their hammers at various points with considerable success.

NOTES WITH REFERENCE TO THE SECTIONS.

The section through the Harrogate anticlinal may be regarded as approximately correct so far as the surface is concerned. The folding of the Yoredale Rocks beneath the Stray is, to a certain extent, hypothetical. When the railway was made across the Stray the beds were observed to be so much disturbed that it was thought by some that the principal axis of elevation was at this point, rather than at the Sulphur Springs.

The Millstone Grit series consist very largely of Shale. It must not be supposed that the relative thickness of the Grits and Shales is accurately delinated in the diagram. Even the Plompton Grits, which form the highest section of the Third Grits in this district, are by no means free from associated Shales.

The section from Malham to Skipton is designed to give an approximate idea of the position and contorted character of the rocks in the vicinity of the Craven fault, and for many miles southward. The surface of the valleys is for the most part thickly covered with glacial clays, sand and boulders; but where exposures of the rock are met with they always exhibit a more or less contorted section. At Malham Tarn the Mountain Limestone extends in more or less horizontal beds on the upturned edges of the Silurian rocks. The grit rocks which occupy the higher ground at Hanlith and Flasby Fells are in the form of synclinals, whilst the summit of the anticlinals occupy the lower parts of the valleys. At Skipton, a Limestone is quarried, which is supposed to be equivalent to the Mountain Limestone at Malham, but this is by no means certain.

SECRETARY'S REPORT.

During the year concluded by the present meeting the Society has held meetings at Dewsbury and Pontefract for the purpose of listening to communications from its members.

On May 24th, a General Meeting was held at the Mechanics' Institution at Dewsbury. Mr. F. W. Reuss, president of the Institution, occupied the chair.

During the summer, arrangements were made for a joint Excursion of the members of the Geologists' Association of London and those of this Society. The combined Associations met at Harrogate on Monday, July 17th, and the geological features of the district were examined under the guidance of Mr. W. H. Hudleston, President of the Geologists' Association, and an account was given of the wells by Dr. Oliver, of Harrogate. On the following day the members visited Knaresborough and Plumpton. On the 19th (Wednesday), the party, now, and for the remaining portion of the excursion, under the guidance of the Honorary Secretary of this Society, left Harrogate and drove to Skipton, spending some pleasant hours at Bolton Abbey and its beautiful environment.

On Thursday, Malham and Gordale were visited, and one portion of the party walked across the moors to the Victoria Cave; and to Settle and Giggleswick. The Museum of the Giggleswick Grammar School was inspected. On the 21st (Friday), the members of the joint Societies proceeded to Clapham. The Caves, Trougill, and Gaping Ghyll Hole were visited. Hitherto the weather had been fine, but the remaining and concluding portion of the excursion was gone through in an extremely heavy downpour of rain. Most of the party however, notwithstanding the rain, visited Norber, with its immense assemblage of ice-born blocks, thence walked round the spur of Moughton Fell, inspected the quarries of slate, with superimposed limestone, and thence walked to Horton-in-Ribblesdale, and returned by train to Skipton. The Saturday's excursion to Lothersdale and Raygill was abandoned.

A detailed description of the excursion is printed in another portion of this volume.

The present meeting, at Pontefract, is the third during the year. The thanks of the Society are due to the Directors of the Dewsbury Mechanic's Institution and to the Corporation of Pontefract for the use of the rooms in which the meetings have been held, and to Mr. Reuss, and Mr. P. F. Lee, the local Secretary at Dewsbury, and to Mr. T. W. Tew, our present chairman, for the kind exertions they have made in the interests of the Society.

The number of members is 203, of whom 22 have compounded for their annual subscriptions and become life members, and the remaining 181 are ordinary members.

The Society has lost one of its most esteemed vice-presidents by the assassination of Lord Frederick Cavendish—a vote expressing the sorrow and condolence of the members was passed at the General Meeting at Dewsbury, and forwarded to Lady F. Cavendish and the Duke of Devonshire. An acknowledgement with thanks for our sympathy was received from Lord Ed. Cavendish in the name of the Duke of Devonshire.

The following is a list of the Local Secretaries and the places which they represent :—

Barnsley	Thos. Lister.
Bradford	Thos. Tate, F.G.S.
Bridlington	G. W. Lamplugh, F.G.S.
Brighouse	T. W. Helliwell.
Driffield	Rev. E. M. Cole, M.A., F.G.S., &c.
Halifax...	W. Cash, F.G.S.
Huddersfield	Peace Sykes
Hull	G. J. Wilson, M.A., &c.
Leeds	J. E. Bedford

Mexbro'	Rowland Gasgoine, F.G.S.
Middlesbrough	Dr. W. Y. Veitch.
Selby	J. T. Atkinson, F.G.S
Sowerby Bridge	J. Marshall,
Thirsk	W. Gregson.
Wensleydale	Wm. Horne.
York	Rev. Thos. Adams, M.A., F.G.S

Proceedings, forwarded from their respective Societies, in exchange for those of our Society, have been received and may be consulted by applying to the Hon. Secretary or at the Museum of the Literary and Philosophical Society at Halifax. The following is an enumeration of them :—

List of Societies whose Proceedings are forwarded to the Yorkshire Geological and Polytechnic Society.

Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association.
Manchester Geological Association.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociètè-Geologique du Nord.
Oversigt ovet det Kongelige Dranske Videnskabernes Selskabs Kjopenhavn.
Museum of Comparative Zoology, Cambridge. U.S.A.
Watford Natural History Society and Hertfordshire Field Club.

Copies of the Proceedings of the Society for the following years may be had on application to the Honorary Secretary Chevinedge, Halifax, price 2s. 6d. each :—1840, 1841, 1842, 1843, 1484-5, 1845-6, 1847, 1848, 1851, 1853, 1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6, 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877, 1878, 1879, 1880, 1881.

During the past year the committee appointed by the Society to superintend the exploration of the Raygill Fissure in Lothersdale have found it advantageous to suspend operations for sometime longer. Mr Spencer, the proprietor of the quarries has very kindly removed a large mass of material which obstructed the entrance to the horizontal portion of the fissure which has now been reached. By this means the operations of your committee will be rendered very much easier and less expensive. It is hoped that early in next year operations will be recommenced.

The Society is again indebted to Mr. W. H, Dalton of H.M. Geological Survey for his assistance in the preparation of the Bibliographical lists and expresses the thanks due for his kindness.

Statement of Receipts and Expenditure of the West Riding Geological and Polytechnic Society.

FROM NOVEMBER 1ST, 1881 TO OCTOBER 30TH, 1882.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	10	0	0	By Cash paid into the Bank	97	2	7
,, Bockett & Co.	91	16	3	,, Edmund Wormald	29	16	3
,, Subscriptions	97	2	7	,, A. Megson	50	19	0
				,, Expenses	11	1	0
				,, Balance in hand	10	0	0
	£198	18	10		£198	18	10

THE TREASURER IN ACCOUNT WITH BECKETT & CO.

	£	s.	d.		£	s.	d.
To Balance at Bank	32	4	7	By Cash from Bank	91	16	3
,, Cash paid to Bank	97	2	7	,, Balance in Bank	38	11	9
,, Interest	1	0	10				
	£130	8	0		£130	8	0

THE TREASURER IN ACCOUNT WITH BECKETT & CO.—CAPITAL ACCOUNT.

	£	s.	d.		£	s.	d.
To Balance at Bank	121	0	0				
,, Cash paid to Bank (Life Subscriptions) ...	25	4	0				
,, Interest	2	14	0	By Balance in Bank	148	18	0

THE TREASURER IN ACCOUNT WITH BECKETT & CO.—RAYGILL QUARRY EXPLORATION FUND.

	£	s.	d.		£	s.	d.
To Balance at Bank	9	4	0				
,, Cash paid to Bank (British Assoctn. Grant)	20	0	0	By Balance in Bank	29	4	0

Examined and found correct, GEO. PATCHETT.

MINUTES OF MEETINGS.

Meeting of the Council at the Museum, Leeds, November 21st, 1881.

Present, Mr. Richard Carter, C.E., in the Chair, Professors Green and Miall, Messrs. Atkinson, Bedford and Ray Eddy, and Honorary Secretary.

The minutes of the last meeting were read and confirmed.

The Honorary Secretary reported that Mr. Denny having declined the office of Assistant Secretary, it had been offered to Mr. Wilson, who had not yet given an answer.

Proposed by Mr. Atkinson, seconded by Mr. Eddy and carried, "That Messrs. Miall, Green, Sladen and Davis be a Revision Committee, and that all papers be submitted to, and approved by, the Committee before publication."

Proposed by Mr. Bedford, seconded by Mr. Eddy, and carried, "That the following accounts be paid:—

E. Wormald	... ...	£4	1*s.*	0*d.*
W. Hunt	... ...	0	10	0
		£4	11	0

Proposed by Mr. Eddy, seconded by Mr. Miall, and carried, "That a special Council meeting be called to consider and revise the rules."

Meeting of the Council at the Museum, Leeds, May 17th, 1882.

Present, Mr. W. Gregson in the chair, Messrs. Atkinson, Bedford, Lee and Honorary Secretary.

The minutes of last meeting were read and confirmed.

Moved by Mr. Atkinson, seconded by Mr. Bedford, and carried, "That the next meeting of the Society be held at Dewsbury, on May 24th, 1882, and that Mr. Councillor Reuss preside, and papers be read by Rev. E. Maule Cole, M.A., and James W. Davis, F.S.A.

Moved by Mr. Bedford, seconded by Mr. Lee, and carried, "That the following accounts be paid :—

Edmund Wormald	£25	15*s.*	3*d.*
Angelo Megson	52	0	6
Petty Cash	10	0	0
	£87	15	9

Moved by Mr. Atkinson, seconded by Mr. W. Lee, and carried, "That a meeting be held in East Yorkshire, and that arrangements be left with Mr. Cole and the Honorary Secretary.

General meeting at the Mechanics' Institution, Dewsbury, on May 24th, 1882.

M. Councillor Reuss presided.

The minutes of the last general meeting at Bradford were read and confirmed.

A resolution was proposed by the Chairman, seconded by Mr. Marriott, J.P., and supported by the Honorary Secretary, as follows, and it was decided to forward the same to Lady Frederick Cavendish and the Duke of Devonshire. "That the Yorkshire Geological and Polytechnic Society desires to express to Lady F. Cavendish, the Duke of Devonshire and the family, their detestation of the crime which has deprived the Society of one of its Vice-presidents, who was esteemed, respected and beloved by all its members; Lord Frederick C. Cavendish was always anxious to support any cause which had for its object advanced education, or the promotion of original scientific research, and worthily adhered to the glorious example set by so many of his ancestors. For this reason this Society regards with the greatest regret and sorrow his untimely end, but are cheered by the thought that his good works will serve as a model for the guidance and encouragement of posterity."

The resolutions were duly acknowledged by Lord Edward Cavendish on behalf of the Duke of Devonshire.

The Chairman delivered an address.

Proposed by Mr. James W. Davis, seconded by Mr. P. F. Lee, and carried, "That the following gentlemen be elected members of the Society :—Charles Combe Arnold, Moor-

land House, Halifax; William Smith, F.S.A.S., Osborne House, Morley; H. G. Brierley, Clara Street, Huddersfield; F. W. Reuss, Dewsbury; C. H. Marriott, J.P., Manor Lawn Dewsbury."

Proposed by Mr. Cheetham, seconded by Mr. Bedford, and carried, "That the next meeting shall be held in Craven, to meet the members of the Geologists' Association from London, instead of East Yorkshire."

Papers were read by the Rev. E. Maule Cole, M.A., "On the White Chalk of Yorkshire."

James W. Davis, "On the Fossil Fish Remains of the Carboniferous Limestone of Yorkshire."

Proposed by Mr. Gray, seconded by Mr. Day, and carried, "That the thanks of this meeting be given to the Chairman and authors of papers."

After the termination of the proceedings, Mr. Reuss entertained the members at the Wellington Hotel.

Meeting of the Council at the Museum, Leeds, August 9th, 1882.

Present, Mr. J. Ray Eddy in the chair, Messrs. Reynolds, Bedford, Cheetham, Tate and Honorary Secretary.

The minutes of the last meeting were read and confirmed.

Proposed by Mr. Cheetham, seconded by Mr. Reynolds, and carried, "That the following accounts be paid :—

A. Megson	... ...	£0 19*s.* 4*d.*
H. Wolff	... ...	0 11 0
		£1 10 4

Proposed by Mr. Tate, seconded by Mr. Bedford, and carried, "That the photographs be obtained from the Autotype Company, on the terms mentioned by the Honorary Secretary."

Proposed by Mr. Cheetham, seconded by Mr. Tate, and carried, "That the photograph for 1883 shall be some object in the East Riding." A section in the Hull and Barnsley railway being suggested.

A joint excursion of the members of the Geologists' Association of London, and the Yorkshire Geological and Polytechnic Society, commenced on Monday, July 17th, and extended over the five following days, when the following localities were visited:—July 17th, Harrogate and district,—18th, Knaresborough, Plumpton, and Brimham,—19th, Harrogate to Skipton,—20th, Malham and Gordale,—21st, Clapham, Norber, and Moughton,—22nd, Raygill.

Meeting of the Council at the Museum, Leeds, October 25th, 1882.

Present, Thos. W. Embleton in the chair, Messrs. R. Carter, T. Lister, and Honorary Secretary.

The minutes of the last meeting were read and confimed.

Proposed by Mr. Carter, seconded by Mr. Lister, "That the following amounts be paid:—

A. Megson	£1	18*s.*	0*d.*
Whitley and Booth	0	13	0
Petty Cash	10	0	0
	£12	11	0

The Honorary Secretary reported that a photograph had been taken at Thornwick Bay, Flamborough Head, and sent to the Autotype Company, with an order to print 250 copies.

Proposed by Mr. Lister, seconded by Mr. Carter, and carried, "That the annual meeting of the members be held at Hemsworth or Pontefract, on November 8th, or 15th, 1882, and that papers be read by Messrs. Lamplugh, Cash, Law and Davis."

Annual general meeting of the members, at Pontefract, on Wednesday, November 15th, 1882.

The members met at the Town Hall, and were conveyed in carriages to Upton Old Hall, where Mr. Tew provided lunch. The new cutting on the Hull and Barnsley railway, close by, was then visited. The Permian Limestone is exposed in a fine section, resting unconformably on the coal measures. Mr. Davis explained the section and its bearings in a brief address. The party then drove back to

Pontefract. At four o'clock the members and friends met at the Town Hall, for the transaction of business.

The chair was occupied by Thomas W. Tew, Esq., J.P.

The minutes of the last general meeting were read and confirmed.

The Honorary Secretary read the annual report and balance sheet from the Treasurer.

Proposed by the Chairman, seconded by Mr. J. Rhodes (Mayor of Pontefract), and carried, "That the report and balance sheet be adopted."

Proposed by the Honorary Secretary, seconded by Mr. G. Scarborough, and carried, "That the following gentlemen be elected members of the Society:—J. H. Phillips, (Scarborough Philosophical Society); John Haigh, Dewsbury; Rev. W. C. Lukis, M.A., Wath Rectory, Ripon; John Rhodes, Mayor of Pontefract; John Shaw, Darrington Hall, Pontefract; George Buckley, Jun., Waterhouse Street, Halifax."

Moved by Mr. James Booth, seconded by Mr. A. Lupton, and carried, "That the Marquis of Ripon be re-elected president for the ensuing year."

Moved by Mr. W. Cash, seconded by Mr. W. Berry, and carried, "That the following noblemen and gentlemen be elected Vice-presidents for the ensuing year:—Earl Fitzwilliam; Duke of Leeds; Earl of Effingham; Earl of Dartmouth; Earl of Wharncliffe; Viscount Galway; Lord Houghton; Vicount Halifax; H. C. Sorby, Esq., L.L.D., F.R.S., &c.; T. W. Tew, Esq,, J.P.; Walter Morrison, Esq., J.P.; W. S. Stanhope, Esq., J.P."

Moved by Mr. R. Carter, seconded by Mr. Eddy, and carried, "That John Brigg, Esq., J.P., F.G.S., be re-elected Treasurer."

Moved by Mr. W. Cash, seconded by Mr. Embleton, and carried, "That James W. Davis, F.S.A., F.G.S., be re-elected Honorary Secretary."

Moved by Mr. J. T. Atkinson, seconded by Mr. W. Rowley, and carried, "That the following gentlemen form the Council of the Society for one year:—Wm. Alexander, M.D., J.P.; R. Carter, C.E., F.G.S.; W. Cheetham; J, Ray Eddy,

F.G.S.; T. W. Embleton, C.E.; E. Filliter, C.E., F.G.S.; Prof. A. H. Green, M.A., &c.; Prof. L. C. Miall, F.G.S.; R. Reynolds, F.C.S.; W. Rowley, F.G.S.; W. Percy Sladen, F.G.S., &c.; W. Sykes Ward, F.C.S."

The Chairman (T. W. Tew, Esq.) gave an address on the "Recent development of the Coal Field in the neighbourhood of Pontefract."

The following papers were read:—

1.—"On the Cliff Section South of Bridlington Quay Harbour." By G. W. Lamplugh, Esq.

2.—"On the Distribution of Flint Implements and Flakes beneath the Peat on the Permian Chain, near Todmorden." By R. Law, Esq.

3.—"Notes on Yorkshire Fossil Mollusca." By W. Cash, Esq., F.G.S., &c.

4.—"On the Section showing the junction of the Coal Measures and Permian Limestone, near Kirk Smeaton." By James W. Davis, Esq.

Moved by the Mayor (John Rhodes, Esq.), seconded by the Vicar (Rev. J. J. Christie, M.A.), and carried, "That the thanks of the meeting be given to Mr. T. W. Tew, for presiding, and to the authors of papers."

At the conclusion of the meeting, the Chairman entertained about sixty of the members and friends at dinner, at the Red Lion Hotel, After the usual loyal toasts, the Chairman proposed "Success to the Society," and coupled with the toast the name of the Honorary Secretary, who replied. Mr. R. Carter proposed "The health of the Chairman," who replied, and the proceedings terminated.

SUMMARY OF GEOLOGICAL LITERATURE RELATING TO YORKSHIRE, PUBLISHED DURING 1882, WITH ADDENDA FOR 1881.

Compiled by **JAMES W. DAVIS.**

1881—ADDENDA.

CROSSKEY, REV., H. W. Note on some additions to the Fauna of the Post-Tertiary Beds at Bridlington, Yorkshire. *Proc. Birmingham Phil. Soc.*, vol. ii., pt. 2, p. 373.

FAIRLEY, T. The Blowing Wells near Northallerton. *Chem. News*, vol. xliv., p. 242.

FLIGHT, W. Report of an Examination of the Meteorites of . . . . . . Middlesbrough, in Yorkshire. *Proc. Roy. Soc.* vol. xxxiii., p. 343.

KIDSTONE, R. On the Structure of Lepidodendron Selaginoides (Sternberg) from the Coal Measures, Halifax, Yorkshire. *Proc. R. Phys. Soc., Edin.*, p. 97.

THORPE, PROF. T. E. Contributions to the History of the Mineral Waters of Yorkshire. *Journ. Chem. Soc.*, p. 497.

1882.

CAMERON, A. G. Subsidences over the Permian Boundary, between Hartlepool and Ripon. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 342.

——— On the Subsidences above the Permian Limestone between Hartlepool and Ripon. *Rep. Brit. Assoc.* for 1881. p. 617.

CASH, W. On the Halifax Hard Seam. *Ibid*, p. 626.

CLARK, J. E. Glacial Sections at York, and their Relation to the later Deposits. *Proc. York, Geol. and Polyt. Soc.*, vol. vii., pt. iv. p. 421, pl. xxiii.; abstract in *Rep. Brit, Assoc.* for 1881, p. 614.

DAKYNS, J. R. On Flots. *Proc. York. Geol. Soc.*, vol. vii., pt. iv., p. 381.

DAVIS, J. W. On the Exploration of a Fissure in the Mountain Limestone at Raygill. *Rep. Brit. Assoc.* for 1881, p. 645.

——— On the Zoological Position of the Genus *Petalorhynchus*, Ag., a Fossil Fish from the Mountain Limestone. *Ibid*, p. 646.

——— On *Diodontopsodus*, Davis. a new Genus of Fossil Fishes from the Mountain Limestone at Richmond, in Yorkshire. *Ibid*, p. 646.

——— Summary of Geological Literature relating to Yorkshire, published during 1881, with Addenda for 1880. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 453.

FAIRLEY, T. On the Blowing Wells near Northallerton. *Ibid*, vol. vii,, pt. iv. p. 409, pl. xxii.; abstract in *Rep. Brit. Assoc.* for 1881, pp. 544, 601.

HARRISON, W. J. Geology of the Counties of England and Wales. 8vo. *London.*

HICK, T. and W. CASH. On a Fossil Stem from the Halifax Coal Measures. *Rep. Brit. Assoc.* for 1881, p. 679.

——— A Contribution to the Flora of the Lower Coal Measures of the Parish of Halifax, pt. iii. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 400, pl. xxi., and abstract in *Rep. Brit. Assoc.* for 1881, p. 679.

HUDLESTON, W. H. Contributions to the Palæontology of the Yorkshire Oolites. *Geol. Mag.*, dec. ii., vol. vii., pp. 145, 193, 241, pls. v., vi.

LAMPLUGH, G. W. On the Bridlington Glacial Shell Beds. *Rep. Brit. Assoc.* for 1881, p. 616.

——— Glacial Sections near Bridlington. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 383. pl. xix.

——— The Bridlington Crag. *Geol. Mag.* dec. ii., vol. ix, p. 383.

MARR, J. E. On Some Sections in the Lower Palæozoic Rocks of the Craven District. *Proc. York. Geol. and Polyt. Soc.*, vol vii., pt. iv., p. 397, pl. xx., and abstract in *Rep. Brit. Assoc.* for 1881, p. 650.

MORTIMER, J, R. On the Sections of the Drift obtained from the New Drainage Works, at Driffield. *Proc. York Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 373, pl. xviii., and abstract *Rep. Brit. Assoc.* for 1881, p. 617.

POULTON, E. B. A Preliminary Account of the Working of Dowkerbottom Cave, in Craven, during August and September, 1881. *Proc. York. Geol. and Polyt. Soc.*, vol. vii.. pt. iv., p. 351, pl. xvii., and abstract *Rep. Brit. Assoc.* for 1881, p. 622.

SPENCER, J. Researches in Fossil Botany. *Rep. Brit. Assoc.* for 1881, p. 627.

——— Notes on Astromyelon and its Root. *Ibid*, p. 628.

——— Astromyelon and its Affinities. *Proc. York. Geol. and Polyt. Soc.*, vol. vii., pt. iv., p. 439.

VINE, G. R. Notes on the Carboniferous Polyzoa of North Yorkshire. *Ibid*, vol. vii., pt. iv., p. 329, pl. xvi.

WOOD, S. V. The Newer Pliocene Period in England. *Quart. Journn. Geol. Soc.*, vol. xxxviii, p. 667, pl. xxvi,

——— The Bridlington Crag. *Geol. Mag.*, dec. ii., vol. vii., p. 192.

LIST OF MEMBERS.

Life Members who have compounded for their annual subscriptions are marked with an asterisk. (*)

ADAMS, THOS., M.A., Clifton Grove House, York.
ADAMSON, S. A., F.G.S., 48, Caledonian Street, Leeds.
AKROYD, ED., F.S.A., &c., Bankfield, Halifax.
*ALDAM, W. J.P., Frickley Hall, Doncaster.
ALEXANDER, WM., M.D., J.P., Halifax.
ANDERSON, C. P., Cleckheaton.
ARNOLD, CHAS. COMBE, Clare Hall, Halifax.
ATKINSON, J. T., F.G.S., The Quay, Selby.

BAILEY, GEO., 22, Burton Terrace, York.
BAINES, SIR EDWARD, J.P., St. Ann's, Burley, Leeds.
BALME. E. B. W., J.P., Cote Hall, Mirfield.
BARBER, W. C., F.R.G.S., The Orphanage, Halifax.
BARTHOLOMEW, CHAS., Castle Hill House, Ealing, Middlesex.
BARTHOLOMEW, C. W., Blakesley Hall, near Towcaster.
BAYLEY, REV. T., Weaverthorpe.
BEAUMONT, HY., Elland.
BEDFORD, JAMES, Woodhouse Cliff, Leeds.
BEDFORD, J. E., Burley View, Leeds.
BERRY, WM., King's Cross Street, Halifax.
BINGLEY, GODFREY, Ash Lea, Cardigan Road, Headingley.
BINNIE, A. R., F.G.S., M. Inst., C.E., Town Hall, Bradford.
BINNS, LEEDHAM, Grove House, Oakenshaw, Bradford.
BOOTH, JAMES, F.G.S., The Grange, Ovenden, near Halifax.
BOOTHROYD, W., Brighouse.
*BOWMAN, F.H., D.Sc., F.R.A.S., F.C.S., F.G.S., Halifax.
BRADLEY, GEORGE, Aketon Hall, Featherstone.
BRIERLEY, H. G., Clara Street, Huddersfield.

*Brigg, John, J.P., F.G.S., Broomfield. Keighley.
*Briggs, Arthur, J.P., Cragg Royd, Rawden, Leeds.
Broadhead, John, St. John's Colliery, Normanton.
Brooke, Ed. jun., F.G.S., Fieldhouse Clay Works, Huddersfield.
Brooke, Lieut.-Col. Thos., J.P., Armitage Bridge, Huddersfield.
Brookes, Rev. W. J., Elmfield Terrace, Halifax.
Buckley, George, jun., Waterhouse Street, Halifax.

Cameron, A. Grant, of H.M. Geological Survey, Brough-on-Humber.
Carr, Wm., Heathfield, Halifax.
Carrington, Thomas, F.G.S., High Hazels, Sheffield.
Carter, R., C.E., F.G.S., Barnsley.
*Cash, W., F.G.S., Elmfield Terrace, Halifax.
Chadwick, Wm., Arksey, Doncaster.
*Charlesworth, J. B., J.P., Wakefield.
Cheetham, W., Horsforth, near Leeds.
Childers, J.W., Cantley, near Doncaster.
*Clark, J. E , B.A., B.Sc., F.G.S., 20, Bootham, York.
Cole, Rev. E. Maule, M A., Wetwang Vicarage, York.
Cole, Geo. B., Wakefield Road, Bradford.
Colefax, J. S., Ash Grove, Bradford.
Cross, Benj. C., C.E., Victoria Chambers, Dewsbury.
Crossley, Newman, Barnsley.
Crowther, F., Northowram, near Halifax.

*Dakyns, J.R., M.A., of H.M. Geological Survey, 28, Jerymn Street, London.
Dartmouth, Earl of, Patshull House, Wolverhampton.
Davey, Hy., Rupert Lodge, Leeds.
*Davis, J. W., F.S.A., F.G.S., F.L.S., Chevinedge, Halifax.
*Denham, Charles, Halifax.
Denison, W. B., J.P., Leeds.
Dewhurst, J. B., Aireville, Skipton.
Dolan, T. M., F.R.C.S.Ed., Halifax.

DRURY, ED., Halifax.
DUNHILL, C. H., M.D., Gray's Court, York.
DUNNING, JOHN, F.G.S., Assoc. Inst. C.E., Middlesborough.
DYSON, W., COLBECK, F.S.A., Wilton Park, Batley.

EDDY, J. RAY, F.G.S., Carlton Grange, Skipton.
EDWARDS, Sir HENRY, Bart. J.P., Pye Nest, Halifax.
EFFINGHAM, Earl of, The Grange, Rotherham.
EMBLETON, T. W., C. E., The Cedars, Methley.
EMMOTT, W., Allerton Place, Halifax.

FARRAR, JAMES, Old Foundry, Barnsley.
FILLITER, E., F.G.S., M. Inst. C.E., East Parade, Leeds.
FITZWILLIAM, Earl, K.G., Wentworth Woodhouse, nr. Rotherham.
FOX, M., jun., Mirfield.
FRAZER, H. J., Poole, near Leeds.

GALWAY, The Viscount, Selby Hall, Bawtry.
GARNETT, WILLIAM, Fairlawn, Ripon.
GASCOIGNE, Col. T., Parlington Park.
GASCOIGNE, ROWLAND, F.G.S., Denaby Collieries, Mexbro', near Sheffield.
GLEADOW, F., 7, Holker Street, Skipton Road, Keighley.
GOODDY, JAMES, Darfield, near Barnsley.
GOUGH, THOS., B.Sc., F.C.S., Elmfield College, York.
*GRAY, THOS. H., Brookleigh, Calverley, Leeds.
GREAVES, J. O., Wakefield.
*GREEN, Prof. A. H., M.A., F.G.S., 14, Ashwood Villas, Headingley.
GREGSON, W., Baldersby, Thirsk.

HAIGH, JOHN, Eightlands, Dewsbury.
HALIFAX, The Viscount, Hickleton Hall, Doncaster.
HALLILAY, J., Burley Road, Leeds.
HARDCASTLE, JOHN, jun., South Milford.
HAWKING, S., Apperley, near Leeds.
HEATON, J. A., Brighouse.

Helliwell, T. W., Brighouse.
Hepworth, S. C., West Park Street, Dewsbury.
Hirst, John, Tadcastle, Dobcross, Saddleworth.
Holgate, Benj., F.G.S., 3, Atkinson Street, Hunslet.
Holt, H. P., C.E., F.G.S., Fairlea, Didsbury, Manchester.
Horne, Wm., Leyburn.
Houghton, Lord, M.A., D.C.L., F.R.S., Fryston Hall, near Pontefract.
Howgate, Wm., 139, Woodhouse Lane, Leeds.

Kell, Arthur A., Barnsley.
Kell, Geo., Barnsley.
Kirby, Joel, Mexbro'.
Knowles, G., Leeds Road, Bradford.

Lamplugh, G. W., F.G.S., West Parade, Bridlington Quay.
Lancaster, Ed., Barnsley.
Laurence, Jno., Barnsley.
Laxton, F., Rastrick, Brighouse.
Leather, J. T., Leventhorpe Hall, near Leeds.
Lee, P. F., West Park Villas, Dewsbury.
Lee, J. Banks, Ripon.
Leeds, Duke of, Hornby Castle, Bedale.
Lister, Thomas, Victoria Crescent, Barnsley.
Lowther, Sir Charles, Bart., Swillington Park, near Leeds.
Lupton, Arnold, F.G.S., M. Inst., C.E., Crossgates, near Leeds.
Lukis, Rev. W. C., M.A., &c., The Rectory, Wath, near Ripon.

Marriott, C. H., J.P., Manor Lawn, Dewsbury.
Marsden, Thos., Paper Mills, Barnsley.
Marshall, John, Sowerby Bridge, near Halifax.
Marshall, Stephen A., B.A., Weetwood, near Leeds.
Mason, C. L., Leeds and County Bank, Leeds.
Maude, E., Middleton Hall, Leeds.
McLandsborough, J., F.G.S., F.R.A.S., The Exchange, Bradford.
Menzies, Jas., Forest House, Ovenden, Halifax.

MIALL, Professor L. C., F.G.S., 173, Belle Vue Road, Leeds.
MILNE, S. MILNE, Calverley House, near Leeds.
MITCHELL, JOHN, Swaith Hall, near Barnsley.
MITCHELL, JOSH., F.G.S., Worsbro' Dale, Barnsley.
MOISER, H. R., F.G.S., 2, South View, Heworth, York.
MORLEY, GEORGE, Garforth, near Leeds.
MORRIL, ROBT. WILSON, Bradford.
*MORRISON, WALTER, J.P., Malham Tarn, near Leeds.
MORTIMER, J. R., F.G.S., Driffield.
MULLER, HARRY, Rawden, near Leeds,
MYERS, W. BESWICK, 13, Park Square, Leeds.

NELSON, HENRY, St. John's Cottage, St. John's Road, Leeds.
NEWHOUSE, WM. HY., Brighouse.
NORTON, WALTER, J.P., Denby Dale, near Huddersfield.

ORMEROD, HANSON, Boothroyd, Brighouse.
ORMEROD, THOMAS, Brighouse.

PARKE, G. H., F.G.S., F.L.S., Infield Lodge, Furness Abbey.
PARSONS, H. FRANKLIN, M.D., F.G.S., 13, Whitworth Road, South Norwood, London, S.E.
POCKLINGTON, HENRY, F.R.M.S., Park Row, Leeds.
PRATT, THOMAS, M.R.C.V.S., Ripon.
PRESTON ALFRED ELEY, C.E., F.G.S., The Exchange, Bradford.

*RAMSDEN, Sir J. W., Bart., M.P., Byram Hall, near Pontefract.
REUSS, F. W., Dewsbury.
REYNOLDS, RICHARD, F.C.S., Cliff Lodge, Leeds.
RHODES, JOHN, Snydale Hall, Pontefract.
RIGGE, S. T., Balmoral Place, Halifax.
RIPON, The Marquis of, K.G., F.R.S., &c., Studley Royal, Ripon.
ROLLIT, A. K., LL.D., D.C.L., F.R.A.S., F.G.S., &c., Cogan House, Hull.
ROWLEY, WALTER, F.G.S., Albion Street, Leeds.
*RYDER, CHARLES, Westfield, Chapeltown, near Leeds.

SADLER, M. T., M.D., Barnsley.

SCARBOROUGH, GEO., Holly Bank, Halifax.

Scarborough Philosophical Society, J. H. PHILLIPS, (Scarbro.')

SEAL, STEPHEN, F.G.S., Darfield Quarries, Barnsley.

SHARP, C. FORBES, Driffield.

SHAW, JOHN, Darrington Hall, Pontefract.

SHAW, THOMAS, J.P., M.P., Allangate, Halifax.

SLADEN, W. P., F.G.S., F.L.S.. Exley House, Halifax.

SLINGSBY, W. C., Carleton, near Skipton.

SMITH, F., Huddersfield Road, Halifax.

SMITH, WM., F.S.A.S., Osborne House, Morley, near Leeds.

SMITHIES, J. W., Elland.

SORBY, H.C., D.C.L., F.R S., F.G.S., Broomhill, Sheffield.

STANHOPE, W. T. W. S., J.P., Cannon Hall, Barnsley.

*STANFELD, A. W., Weetwood Grove, near Leeds.

STEEL, R. ELLIOTT, M A., 28, Blenheim Road, Manningham, Bradford.

STEVENSON, JOHN, Ormesby Packend, Middlesborough.

STOTT, W., Greetland, near Halifax.

STRANGWAYS, C. FOX, F.G.S., of H.M. Geological Survey. 5, Belgrave Crescent, Scarborough.

*STRICKLAND, Sir CHARLES, W., Bart., Hildenley, Malton.

STUBBINS, JNO., F.G.S., Chester Cottage, Old Lane, Halifax.

SWALLOW, D., Gasworks, Bradford.

SYKES, PEACE, 33, Estate Buildings, Huddersfield.

TATE, THOMAS, F.G.S., 4, Kingston Road, Leeds.

TENNANT, J. R., Kildwick Hall, near Skipton.

TETLEY, F. W., Foxhills, Weetwood, near Leeds.

TETLEY, C. F., Spring Road, Headingley, near Leeds.

*TEW, THOMAS W., J.P., Carleton Villa, near Pontefract.

THOMPSON, R,, Park Street, The Mount, York.

*TIDDEMAN, R. H., M A., F.G.S., of H.M. Geological Survey, 28, Jermyn Street, London.

TOWNEND, WALTER, Halifax.

TURNER, R. BICKERTON, J.P., East Parade, Leeds.

VILLIERS, J., East Gate, Beverley.
VEITCH, W. Y., M.D., 37, Grange Road, Middlesborough.

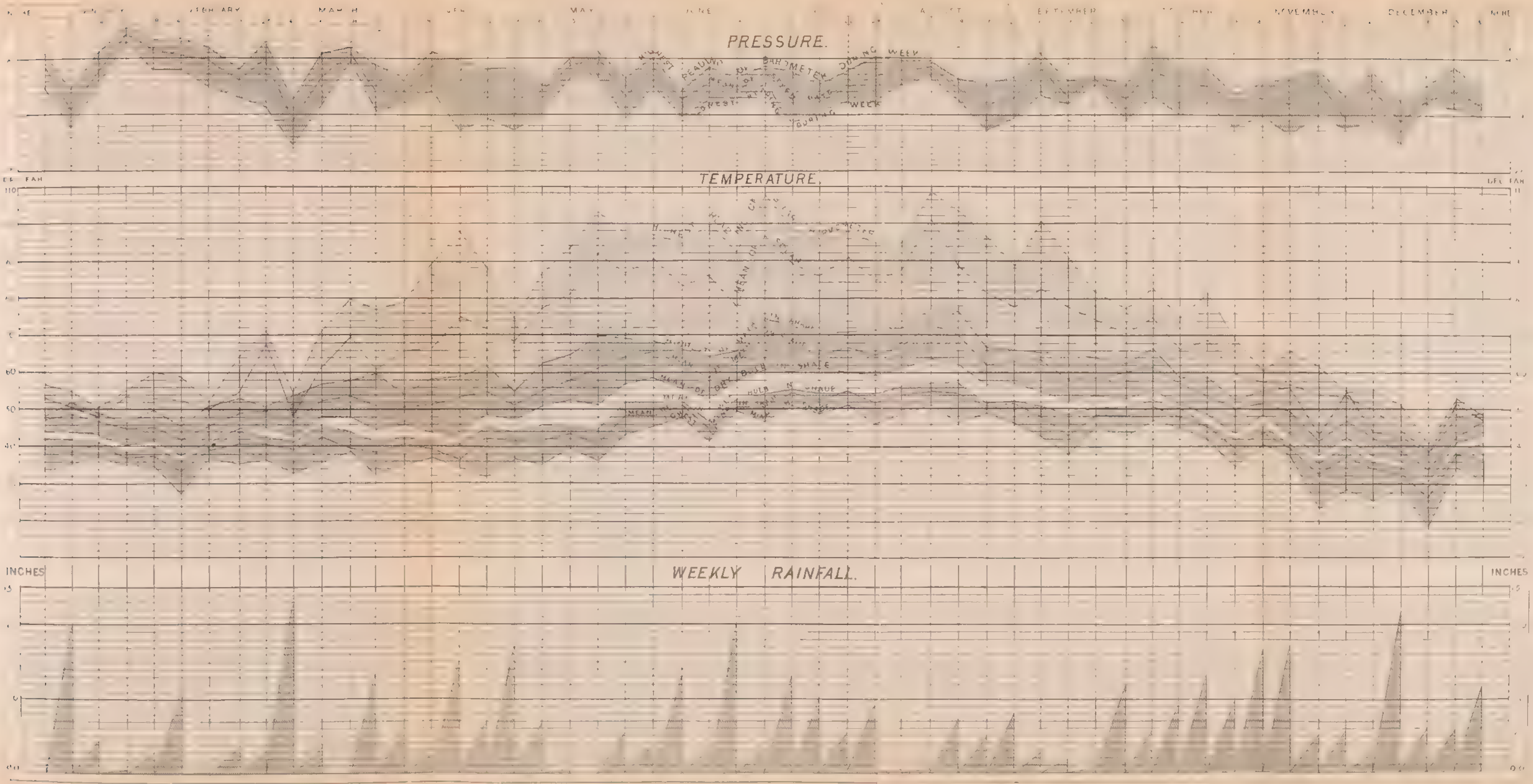
WALKER, CHARLES, Little Houghton, Darfield.
WARD, CHRISTOPHER, F.L.S., F.Z.S., Halifax.
WARD, GEORGE, F.C.S., Leeds.
*WARD, J. WHITELEY, Halifax.
WARD, JOHN, F.G.S., 23, Stafford Street, Longton, Staffordshire.
WARD, W. SYKES, F.C.S., Denison Hall, Hanover Square, Leeds.
WARRINGTON, JOHN, Worsbro', near Barnsley.
WENTWORTH, F. T. W. VERNON, Wentworth Castle, Barnsley.
WHARNCLIFFE, Earl of, Wortley Hall, Sheffield.
WHEATLEY, CHARLES, Sand House, Mirfield.
*WHITELEY, FREDK., Clarehall Road, Halifax.
WILSON, E. J., M.A., 6, Whitefriars' Gate, Hull.
WOOD, W. H., Albion Place, Leeds.
WOOD, W. H., Boro' Analyst, Halifax.
WOODALL, J. W., J.P., F.G.S., Old Bank, Scarbro'.
WOODHEAD, JOSEPH, J.P., Woodthorpe, Huddersfield.

⁂ It is requested that Members changing their residence will communicate with the Secretary.

Meteorology of Bradford for 1882.

WEEKLY PRESSURE, TEMPERATURE, & RAINFALL, RECORDED AT THE EXCHANGE, BRADFORD,

by John McLandsborough, F.R.A.S., F.M.S., F.G.S. and Alfred Eley Preston, Assoc. M. Inst. C.E., F.M.S., F.G.S.



Bailey Surveyors Lith. [illegible] Bradford

METEOROLOGY OF BRADFORD FOR 1882.

Computed from daily observations made at the Exchange, Bradford,

By John McLandsborough, F.R.A.S., F.M.S., F.G.S., and Alfred Eley Preston, Asso. M. Inst. C.E., F.M.S., F.G.S.

Latitude, 53 deg. 47 min. 38 sec. N.; longitude, 1 deg. 45 min. 4 sec. W. Height above mean sea level, 366 ft.

Months	Pressure of Atmosphere in Month: Highest Reading of Barometer	Date	Lowest Reading of Barometer	Date	Range	Corrected for Capillarity and Temperature: Mean	Mean of 14 Years	Temperature of Air in Month: Highest	Date	Lowest	Date	Range	Mean: Of all Highest	Of all Lowest	Daily Range: Mean	Mean of 14 years	Of Dry Bulb
	Ins	On	Ins	On	Ins	Ins	Ins	Deg	On	Deg	On	Deg	Deg	Deg	Deg	Deg	Deg
January	[illegible]	14th	[illegible]	31st	[illegible]	[illegible]	[illegible]	[illegible]	6th	[illegible]	29th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
February	[illegible]	[illegible]	[illegible]	2?th	[illegible]	[illegible]	[illegible]	[illegible]	26th	17·6	2nd	26·4	45·5	[illegible]	[illegible]	[illegible]	[illegible]
March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19th	[illegible]	22nd	27·1	51·1	[illegible]	11·6	11·3	[illegible]
April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	62·3	[illegible]	[illegible]	16th	30·3	[illegible]	[illegible]	[illegible]	13·5	41·9
May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33·7	61·3	44·4	[illegible]	14·6	[illegible]
June	[illegible]	1st	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74·4	30th	41·0	18th	[illegible]	[illegible]	[illegible]	13·4	[illegible]	[illegible]
July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1st	[illegible]	[illegible]	7·8	[illegible]	[illegible]	[illegible]	[illegible]	57·[illegible]
August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11·4	[illegible]
September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2nd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2nd	[illegible]	26th	[illegible]	[illegible]	45·[illegible]	[illegible]	[illegible]	[illegible]
November	[illegible]	14th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6th	24·0	[illegible]	[illegible]	46·4	[illegible]	[illegible]	[illegible]	41·8
December	[illegible]	[illegible]	[illegible]	4th	[illegible]	[illegible]	29·451	63·2	30th	18·6	11th	34·6	[illegible]	[illegible]	7·1	8·4	37·7
Means, or totals	[illegible]		[illegible]		[illegible]	29·465	29·493	[illegible]		34·2		[illegible]	54·8	43·4	11·4	11·9	[illegible]
Means of 14 years	30·064		[illegible]		1·182	29·493	29·493	64·9		33·4		31·5	54·7	42·7	12·0	11·9	48·0

Months	Adopted Mean Temperature: Of Air: Mean	Mean of 14 years	Of Evaporation	Dew Point	Vapour: Elastic Force	In a Cubic Foot of Air: Mean	Short of Saturation	Degree of Humidity (Complete Saturation = 100): Highest	Date	Lowest	Date	Mean	Mean of 14 years	Mean Weight of a Cubic Foot of Air	Highest Reading of Max. Thermometer in Rays of Sun	Date	Mean Reading of Max. Thermometer in Rays of Sun
	Deg	Deg	Deg	Deg	Ins	Grs	Grs	0–100	On	0–100	On	0–100	0–100	Grs	Deg	On	Deg
January	41·[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2?th	[illegible]	6th	[illegible]	[illegible]	[illegible]	[illegible]	25th	[illegible]
February	43·0	[illegible]	41·4	[illegible]	·242	2·8	0·4	[illegible]	26th	[illegible]	16th	87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March	44	[illegible]	42·[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1st	55	2?th	81	[illegible]	541	[illegible]	12th	[illegible]
April	44·3	[illegible]	42·2	[illegible]	[illegible]	2·8	[illegible]	[illegible]	5th	44	21st	81	78	[illegible]	[illegible]	11th	[illegible]
May	51·[illegible]	[illegible]	46·4	41·3	[illegible]	2·9	1·3	[illegible]	1st	[illegible]	1?th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June	54·5	[illegible]	[illegible]	[illegible]	[illegible]	3·4	1·4	[illegible]	22nd	[illegible]	[illegible]	71	72	[illegible]	[illegible]	[illegible]	[illegible]
July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1·5	[illegible]	21st	45	17th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1·6	[illegible]	1?th	41	11th	[illegible]	74	[illegible]	[illegible]	[illegible]	[illegible]
September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2?th	41	6th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	[illegible]	[illegible]	45	[illegible]	[illegible]	[illegible]	92	15th	[illegible]	5th	87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
November	[illegible]	[illegible]	[illegible]	[illegible]	·219	2·5	[illegible]	[illegible]	5th	[illegible]	2?th	84	[illegible]	[illegible]	[illegible]	[illegible]	61·6
December	37·4	[illegible]	36·2	34·6	·210	[illegible]	[illegible]	97	27th	44	11th	[illegible]	[illegible]	515	[illegible]	[illegible]	45·1
Means, or totals	48·2	47·8	45·1	41·9	·271	3·1	0·9	94		51		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
Means of 14 years	47·8	47·8	44·7	41·3	·267	3·1	0·9	94		59		79	79	[illegible]	91·2		70·5

Months	Wind: Highest Estimated Strength	Date	Mean Estimated Strength	Direction, Relative Proportion of, at 9 a.m.: N	NE	E	SE	S	SW	W	NW	Mean Amount of Cloud	Rain: Number of Days it fell	Amount Collected	Greatest Daily Fall	Date	Mean of Fourteen Years	Mean of seven Years … 65½ft above surface	Mean of … Years at Town Hall and Midland Railway Station on surface of ground	Greater Fall on surface at Town Hall & Mid. Ry. Station than at 65½ft above surface of Exchange: Depth in Inches	Percentage of fall at Exchange
	0–12	On	0–12	No	No	No	No	No	No	No	No	0–10	No	Ins	Ins	On	Ins	Ins	In	Ins	Per cent
January	3·5	8th	1·1	0	0	2	6	1	12	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
February	[illegible]	[illegible]	1·2	0	[illegible]	[illegible]	2	4	10	[illegible]	6	7·7	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March	2·5	[illegible]	1·4	0	1	0	1	[illegible]	21	5	[illegible]	[illegible]	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11·7
April	2·5	24th	1·0	0	[illegible]	5	[illegible]	1	5	[illegible]	[illegible]	[illegible]	[illegible]	4·11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May	[illegible]	1st	0·8	[illegible]	5	[illegible]	[illegible]	3	[illegible]	[illegible]	4	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June	[illegible]	3rd	0·9	0	2	[illegible]	7	0	[illegible]	[illegible]	5	[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
July	[illegible]	[illegible]	[illegible]	1	1	[illegible]	[illegible]	[illegible]	13	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August	[illegible]	2nd	1·1	1	2	0	3	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
September	[illegible]	2nd	[illegible]	0	[illegible]	1	4	0	[illegible]	4	[illegible]	[illegible]	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	[illegible]	1·6	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	6	6	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
November	[illegible]	22nd	1·1	[illegible]	[illegible]	[illegible]	3	0	[illegible]	5	8	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
December	[illegible]	5th	[illegible]	1	[illegible]	[illegible]	1	0	11	2	10	[illegible]	25	4·51	1·61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11
Means, or totals	2·5		[illegible]	[illegible]	32	[illegible]	[illegible]	16	[illegible]	54	[illegible]	[illegible]	237	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Means of 14 years	2·91		1·11	25	52	27	39	23	72	74	53	6·6	186	31·27	[illegible]		[illegible]				

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, AND RAINFALL, FROM 1869 TO 1882, INCLUSIVE.

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, [illegible]

The highest and lowest barometric readings for each month, [illegible] the monthly [illegible] are recorded, while the mean pressure is deduced from the daily observations corrected for [illegible], temperature, and [illegible] range. To [illegible] for altitude, [illegible] the air temperature [illegible] and [illegible] being 32 inches at sea level, [illegible]

The adopted mean temperature of air is deduced from the dry and wet bulb, maximum and minimum readings, the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from the daily readings of the dry and wet bulb thermometers, by Glaisher's Hygrometrical Tables, sixth edition.

The sun thermometer has a black bulb enclosed in vacuum.

The direction of the wind is [illegible] as indicated by vane, and not by the [illegible]. Its pressure is estimated by a scale [illegible] from 0 to 12, the [illegible] of the [illegible] [illegible] to the [illegible] the pressure [illegible] [illegible] The highest [illegible] [illegible] [illegible] at the Exchange, which [illegible] [illegible] [illegible] [illegible] in this country [illegible]

The amount of cloud is estimated by a scale ranging from 0 to 10.

Year	Pressure: Highest: Reading of Barometer during Year	Date	Lowest: Reading of Barometer during Year	Date	Temperature: In Shade: Highest: Reading of Maximum Thermometer during Year	Date	Lowest: Reading of Minimum Thermometer during Year	Date	Last and First Frost of Season: Date of Last Frost	Date of First Frost	In Sun's Rays: Highest: Reading of Solar Thermometer during Year	Date	Humidity (Complete Saturation = 100): Highest: Degree of Humidity during Year	Date	Lowest: Degree of Humidity during Year	Date	Rain: Total for Year	Mean Yearly Rainfall at Town Hall & Midland Railway Station on surface of ground	Greater fall on surface at Town Hall & Mid. Ry. Station than at 65½ ft. above surface at Exchange: Depth in Inches	Percentage of fall at Exchange	Greatest Daily Fall during Year	Date	Snow: Last and First Snow of Season: Date of Last Snow	Date of First Snow
	Ins		Ins		Deg		Deg				Deg		0–100		0–100		Ins	Ins	In	Per cent	Ins			
1869	[illegible]	Dec 6	28·560	Feb 1	[illegible]	Aug 30	[illegible]	Dec 28	Mar 27	Oct 20	[illegible]	Aug 30	[illegible]	Feb 8	4	Sept 24	[illegible]				[illegible]	Dec 10	April 3	Oct 9
1870	[illegible]	Jan 19	[illegible]	Jan 8	[illegible]	July 25	11·6	Dec 24	Mar [illegible]	Nov [illegible]	[illegible]	July 26	98	Jan 29	40	July 14	[illegible]				[illegible]	June 18	Mar 24	Nov 15
1871	30·152	Mar 22	[illegible]	Jan [illegible]	[illegible]	Aug 12	6·7	Jan 1	April 11	Nov [illegible]	[illegible]	July 17	96	July 7	43	Nov 2	[illegible]				0·95	June 16	Mar 15	Nov [illegible]
1872	[illegible]	April 6	[illegible]	Jan 24	[illegible]	July 23	[illegible]	Mar 27	Mar 27	Nov 19	[illegible]	Aug 19	[illegible]	Mar 22	15	Sept 23	[illegible]				2·40	June 19	Mar 11	Nov 13
1873	30·338	Feb 18	[illegible]	Jan 20	[illegible]	July 23	[illegible]	Feb 21	Mar 14	Nov 5	124·6	July [illegible]	100	Dec 11	41	May [illegible]	[illegible]				[illegible]	Aug 4	April [illegible]	[illegible]
1874	[illegible]	Mar 6	[illegible]	Dec 11	[illegible]	July 20	15·0	Dec 31	Mar 12	Nov 11	[illegible]	July [illegible]	100	Feb 6	42	May [illegible]	[illegible]				[illegible]	Dec 7	May 9	Nov 16
1875	[illegible]	July 7	[illegible]	Nov 10	[illegible]	Aug 17	[illegible]	Jan 1	Mar 22	Nov 26	[illegible]	July 6	100	Jan 23	43	[illegible]	[illegible]				[illegible]	Nov 15	Mar [illegible]	Nov [illegible]
1876	[illegible]	Jan 15	[illegible]	Dec 4	[illegible]	July 17	[illegible]	Jan 9	April 15	Nov 9	[illegible]	July 16	[illegible]	Oct 4	[illegible]	May [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Oct 9	April [illegible]	Nov 3
1877	[illegible]	Oct 6	[illegible]	Nov 29	[illegible]	June 19	20·0	Mar 1	May 4	Oct 19	116·4	June [illegible]	100	Oct [illegible]	[illegible]	May [illegible]	[illegible]	[illegible]	[illegible]	11·19	[illegible]	July 16	May [illegible]	Oct 15
1878	[illegible]	Mar [illegible]	[illegible]	April 1	[illegible]	July [illegible]	[illegible]	Dec [illegible]	April 6	Nov [illegible]	[illegible]	July 12	[illegible]	Jan 13	[illegible]	Aug [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Aug 14	April 1	Nov 8
1879	[illegible]	Dec 13	[illegible]	Dec 10	[illegible]	July 30	[illegible]	Dec 7	May [illegible]	Nov 14	101·2	Aug 13	[illegible]	Oct 7	51	Dec [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	June 8	May 7	Nov 20
1880	[illegible]	Jan 7	[illegible]	Nov 16	[illegible]	Sept 5	26·8	Jan 20	Feb 23	Oct 26	112·0	Aug 13	[illegible]	Dec 15	[illegible]	May [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Oct 27	Mar 2	Oct 27
1881	[illegible]	May 10	[illegible]	Oct 14	[illegible]	July 6	12·0	Jan 26	April 21	Oct 17	116·5	June 1	[illegible]	Oct 14	[illegible]	May 1	[illegible]	[illegible]	[illegible]	11·26	[illegible]	Oct 15	April 20	Oct [illegible]
1882	30·544	Jan. 18	28·452	Mar 1	77·4	Aug. 12	18·6	Dec. 11	April 16	Nov. 12	[illegible]	Aug. 9	[illegible]	Nov. 5	36	May 18	[illegible]	43·103	3·420	[illegible]	1·008	Dec. 6	Mar. 21	Nov. 19
Means	30·328		28·309		83·1		16·9				119·9		99		43		31·268	39·601	3·860	11·08	1·359			

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and [illegible] feet above mean sea level. The mean yearly [illegible] collected at the Exchange [illegible] [illegible] with 1869 [illegible] inches, and for the last seven years [illegible] inches. A rain gauge [illegible] [illegible] known to [illegible] [illegible] on the surface of open ground adjacent thereto in 1875 [illegible] fixed on the surface of [illegible] near to the Town Hall and the Midland Railway Station, between which the Exchange is situated, [illegible] [illegible] [illegible]. The mean yearly fall [illegible] ending with 1882 [illegible] [illegible] cent. more than that at the Exchange. [illegible] for concluding that not only are the differences [illegible] percentage due to the [illegible] [illegible] [illegible] [illegible] at different [illegible] [illegible] of the Exchange, but that [illegible] [illegible] [illegible] precipitation, rather than to [illegible] [illegible] [illegible] [illegible] the mean of [illegible] [illegible] [illegible] [illegible]

All the instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

The mean of fourteen years, where given, is for that period **ending with 1882.**

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

New Series, Vol. VIII., Part II., pp. 157 to 293.

With Ten Plates.

Edited by JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

1883.

YORKSHIRE

Geological and Polytechnic Society.

OFFICERS.

President:

The Marquis of Ripon, K.G., &c.

Vice-Presidents:

Duke of Leeds.
Earl of Dartmouth.
Earl of Effingham.
Earl Fitzwilliam.
Earl of Dartmouth.
Lord Houghton.
Viscount Halifax.
Viscount Galway.
Louis J. Crossley, J.P., &c.
Walter Morrison, J.P., &c.
Thos. Shaw, M.P.
H. C. Sorby, LL.D., F.R.S.
W. T. W. S. Stanhope, J.P.
Thos. W. Tew, J.P.

Treasurer:

William Cash, F.G.S.

Honorary Secretary:

James W. Davis, F.S.A., F.G.S., &c.

Council:

W. Alexander, M.D.
R. Carter, C.E.
W. Cheetham.
J. R. Eddy, F.G.S.
T. W. Embleton, C.E.
E. Filliter, C.E.
Prof. A. H. Green, M.A.
Prof. L. C. Miall, F.G.S.
G. H. Parke, F.G.S.
R. Reynolds, F.C.S.
W. Rowley, F.G.S.
W. S. Ward, F.C.S.

Local Secretaries:

Thos. Lister, Barnsley.
Thos. Tate, F.G.S., Bradford.
G. W. Lamplugh, F.G.S., Bridlington.
T. W. Helliwell, Brighouse.
P. F. Lee, Dewsbury.
Rev. E. M Cole, M.A., F.G.S., &c., Driffield.
George Patchett, jun., Halifax.
Peace Sykes, Huddersfield.
G. J. Wilson, M.A., &c., Hull.
J. E. Bedford, Leeds.
Rowland Gascoigne, F.G.S., Mexbro'.
Dr. W. Y. Veitch, Middlesbrough.
J. T. Atkinson, F.G.S., Selby.
J. Marshall, Sowerby Bridge.
W. Gregson, Thirsk.
Wm. Horne, Wensleydale.

PROCEEDINGS OF THE YORKSHIRE
Geological & Polytechnic Society.

Vol. VIII., Part II.

WITH TEN PLATES.

Edited by JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

1883.

CONTENTS.

PAPERS:— PAGE.

1. "Address on the Connection between Geology and Archæology." By the Rev. W. C. Lukis, M.A., F.S.A. 157
2. "Notes on the Carboniferous Polyzoa of West Yorkshire and Derbyshire.—*(An attempt to identify Phillips' Species)*." By George Robert Vine 161
3. "On the Geology of Palestine." By W. H. Hudleston, M.A., F.G.S., &c. 174
4. "A Glacial Deposit near Doncaster." By Thomas Hill Easterfield 212
5. "Notes on a Visit to the Channel Tunnel." By Arnold Lupton, M. Inst. C.E., F.G.S., &c. 213
6. "On the Sequence of the Permian Rocks, near Ripon." By the Rev. J. S. Tute, B.A.... 218
7. "Some Indications of a Raised Beach at Redcar." By the Rev. J. S. Tute, B.A. 220
8. "On the Raised Beaches on the North-East Coast of Yorkshire." By W. Y. Veitch, Esq., M.D. 221
9. "Notes on the Carboniferous Entomostraca and Foraminifera of the North Yorkshire Shales." By George Robert Vine 226
10. "Glacial Sections near Bridlington. Part III. The Drainage Sections." By G. W. Lamplugh 240
11. "On the Shell Mounds or Kitchen Middens at Spurn Point." By H. Bendelak Hewetson. *(Abstract.)* 254
12. "The Young Stage of Some Carboniferous Cephalopoda." By Wm. Cash, F.G.S. *(Abstract.)* 254
13. "Biographical Notices of Eminent Yorkshire Geologists. II., 'Adam Sedgwick." By T. M'Kenny Hughes, M.A., Woodwardian Professor of Geology, Cambridge 255
14. "Geological Excursion to Holderness, the Kilnsea Shell Mounds, Spurn Point, and the Pile Dwellings at Ulrome." By James W. Davis, F.G.S. 269
15. Secretary's Report and Balance Sheet 276-280
16. Minutes 281
17. Summary of Geological Literature 285
18. List of Members 287

Meteorology of Bradford, for 1883. By J. M'Landesborough, F.G.S., and A. E. Preston, F.G.S.

LEEDS:

Printed by A. Megson and Sons, Bank Street.

1884.

PROCEEDINGS

OF THE

YORKSHIRE

GEOLOGICAL AND POLYTECHNIC SOCIETY.

Edited by JAMES W. DAVIS, F.S.A., F.G.S., &c.

1883.

ADDRESS ON THE CONNECTION BETWEEN GEOLOGY AND ARCHÆOLOGY. BY THE REV. W. C. LUKIS, M.A., F.S.A.

We are met together to welcome a society whose noble President is in a far distant land, occupying the highest post of distinction and trust that can be conferred by Her Majesty upon one of her subjects. The citizens of Ripon, and residents in the neighbourhood, rejoice to see him discharging the responsible duties of his high Vice-regal office with that energy and unremitting attention to public business, which are a strongly marked feature in his character; but if any one has reason to regret that his Lordship is in India, and not in this room to-day, it is myself.

Between forty and fifty years ago I spent a most enjoyable day in an aquatic excursion from Cambridge down the sedgy river Cam as far as Ely, in company with four gentlemen, whose names probably not one person in this room is ignorant of, and with one or more of whom some here present have had intimate personal acquaintance. With that too-short day my geological study, practically applied, may be said to have begun and ended. These four gentlemen were Professors Sedgwick, Phillips, Henslow, and Ansted. It was a day of my Cambridge life which I have always cherished in memory.

Your accomplished Secretary, Mr. James W. Davis, has written an exceedingly interesting biographical notice of Professor Phillips, who, for the long period of thirty years was so actively engaged in investigating Yorkshire rocks, and in giving lectures in the county, that he might almost be claimed as a fellow-countryman of yours; which notice has been printed in Vol. VIII., of the Society's *Proceedings.* In it he remarks:—"My recollection is very fresh of his kind "and genial face, his winning and encouraging smile, the ever-ready "and wise words with which he brightened and enlivened the most "perplexing question, and the deep knowledge and great experience "which lay below and prompted all his observations." These remarks are especially applicable to Professor Sedgwick, who, being a Yorkshireman by birth, possessed in a remarkable degree the faculty of attracting the admiration, and retaining the affectionate respect of all the members of the University, old and young. If his features were somewhat rugged, his eloquence and animation in public lecturing, and in social converse, were most pleasing, and his soul overflowed with so much wit and humour that he was a most agreeable and fascinating companion. But over and above these attractive qualities, he was an earnest and sincere believer in the Great and Almighty Architect of the Universe, and, when lecturing, was always careful to impress upon the minds of the young students of science that no geological discoveries would ever be found to conflict with the truth of the Sacred History.

The title of the Institution, which we have the honour to welcome to this city, would seem to imply, upon the face of it, that its sphere of inquiry is limited to the geology of Yorkshire, and to those natural formations which, by the application of machinery and other appliances are rendered beneficial to mankind.

I propose to point out in very few words in my brief address, that this would be a too-narrow view, and in what manner archæology is connected with it. If the researches of the society's members were confined to the field of geology and mechanical science alone, however important to the community at large, and interesting to many, they might prove, they would not satisfy and interest everybody. All of us are not geologists, nor are we all absorbed in matters relating to practical engineering; and those among us who reside on the extreme eastern verge of the Riding, far removed from the great centres of mineral wealth and industrial activity, cannot be expected to take the most lively pleasure in viewing and considering the consecutive order, the dip, the contortions and the faults of strata; in discoveries of new coal and ironstone beds, and lead veins; or in new and ingenious mechanical contrivances for extracting minerals from the earth, and making them fit for man's use.

But under the further title of Polytechnic, much is included that might be thought, and perhaps has been thought, outside the society's field of operations, and awakens the interest of non-geologists. Archæology, *e.g.* in many of its bearings is so interwoven with, or rather dovetailed into geology, mineralogy, and the arts and sciences, that it cannot be entirely excluded, and the society has wisely opened its portals to it. It is true that in its origin the Institution was founded for the purpose of directing the studies of its members to those subjects which have special reference to the geology and industries of the West-Riding of Yorkshire, and for many years this object was kept steadily in view, but after a while one member, and then another, without protest from the governing body, gave papers on British, Roman, and other remains, not found in the county, some of which papers bore in no sense upon the geology and industries of the Riding. I confess I was one of the culprits in 1869, at which period an unusual number of alien subjects were introduced, and no doubt I was one of the main causes of a desire on the part of the Council, in 1872, to restore the society to what was conceived to be its original legitimate work.

I have said above that there are questions relating to manufacturers and industry generally, which, being archæological, are not unworthy of the society's recognition or inconsistent with its aim. The tools and weapons of the primitive inhabitants of Yorkshire, and the materials with which they have been formed; the clothing which covered the people, whether manufactured out of woollen stuff or leather; the art of the primeval potter; the implements employed in agricultural and mining purposes; what grain and fruits of the earth were cultivated; what animals were bred; what were the horse trappings and chariots; what the design, materials, and fabrication of personal ornaments; of what kind were their dwelling-houses and fortresses; and even the materials and construction of their coffins—all these matters, which belong to the domain of archæology, are yet legitimate branches of scientific study which no Polytechnic Society can fairly exclude, for in tracing out the development of industry no hard and fast line could be drawn beyond which research would be unnecessary and uninstructive, not to say unattractive to some among us.

These remarks will also apply to the Roman, Saxon, Danish, and Norman occupation of Yorkshire, and to the influences which the productions of these invading races have exercised upon the modern industries of the county, and of the country generally. There is no doubt that each of these peoples have left some traces of their skill and ingenuity in manufacture among the subjugated and oft-times cruelly oppressed inhabitants, of which we are reaping the benefit now; and if it had not been for archæological researches, and the publication of those researches, many amongst us would never have known to what extent we are indebted to them for much that we may have vauntingly and in our ignorance taken credit to ourselves for having originated. The explorations of antiquarians have been instrumental, not only in bringing to light numerous articles of various kinds which for honest purity of materials, elegance of form and design, and excellence of workmanship cannot be excelled in the present day, but which on being reproduced by our manufacturers have found a ready sale, because the public eye has been captivated, and public taste educated. Thus, moderns have imitated the works of the ancients, by doing which, they have to some extent confessed their own inferiority; and this has been the humbling but beneficial result of archæological investigation.

NOTES ON THE CARBONIFEROUS POLYZOA OF WEST YORKSHIRE AND DERBYSHIRE—*(AN ATTEMPT TO IDENTIFY PHILLIPS' SPECIES).*

BY GEORGE ROBERT VINE.

FOR many years past I have made several unavailing attempts to identify, and re-describe, the Carboniferous Polyzoa of our older Palæontologists. I ascribe my failure rather to the scarcity of material than to any want of distinctness on the part of the original describers. There is, as a matter of course, the original specimens—especially of Phillips and McCoy—but these were not available for my work, and I prefered to depend upon later findings, comparing the new with the written details of authors. It is pretty well known, that after the publication of Goldfuss' Petrifacta Germaniæ, that this work was the source of much of our information respecting Fossil Zoophyta; and accordingly many of our British examples were furnished with the generic, if not the specific names of Goldfuss. In the Petrifacta there are but few species figured or described from Carboniferous rocks. To this cause we owe the original descriptions of Phillips, who, writing only a year or so after the issue of the German work, was able to furnish a rather goodly list of Carboniferous species. In his edition of the Geology of Yorkshire, p. 195 (1829 Ed.) Phillips says "Few of the Mountain Limestone districts of England are deficient in remains of Corals, Crinoidea, &c., whether as in Derbyshire and Mendip we contemplate the lower thick mass of Calcareous rock, or as in the North-West of Yorkshire, and in Northumberland examine the thinner portion which alternate with shales, gritstones, &c. Several of the same species are common in the whole range of the formation, and perhaps, if the local catalogues were more complete and more correct, it is probable that a very general conformity would be found to prevail in this respect."

Since the issue of the Geology of Yorkshire, a very steady progress has been made in either the discovery of new Carboniferous species of Polyzoa in Great Britain, or in showing the wider range of species identical with those described by Phillips. McCoy in his various works added much to our knowledge of Carboniferous Polyzoa,—and later still Prof. Young, and Mr. John Young, of

Glasgow have added to the number of species previously described, and have furnished many interesting details of heretofore unknown characters in some of the species described by Phillips in his "Palæozoic Fossils." Mr. Robert Etheridge, jun., has likewise done good work in his professional capacity on the Scotch Geological survey.

The present paper is the result of a careful study, for the purpose of identification, of the types of John Phillips, as described and figured in the Geology of Yorkshire, or referred to in the Palæozoic Fossils. I have previously examined some of the North Yorkshire Polyzoa,* and I have shown that many of these have a closer relationship with Scotch, than with Yorkshire types. The remarks which will follow are founded upon a very fine series of Carboniferous Polyzoa from Derbyshire and Yorkshire, collected by Mr. John Aitken, F.G.S., of Manchester. The Derbyshire species have a closer relationship with the Yorkshire, or Phillips' types, but hardly any with the Irish or Scotch examples bearing the same names.

Mr. Phillips in the work already cited *(Geol. of Yorks.)*, and later still in the Palæozoic Foss. of Devon, &c., described and figured as Zoophyta, a goodly number of Polyzoa. Some of the species in the latter work are identical with those found in the Carboniferous rocks of Derbyshire, Yorkshire, Wales, and Scotland, in fact, many of the species are widely distributed in the Limestones and Shales generally. At the time when Phillips wrote, very little attention was given to either classification or growth, hence the multiplicity of species if the fragments found differed in the least particular from others that had been previously noted. There was no fixed rule given for the purpose of comparison, sometimes a cast, or the reverse would be described as a new species, and in all probability the obverse of one or other of those would be again given as likewise new. Several of the species figured in the Geology of Yorkshire are in this chaotic condition, and there is a great difficulty in the proper identification of species whenever or wherever new ground is broken. Because of this very plausible demurrer others have added to the confusion, and the fresh findings have been again christened, perplexing alike the Palæontologist as well as the ordinary Geological student. Phillips has described nine species of Retepora (Fenestella), only three of which can be retained as tpyical, *R. membranacea*, *nodulosa, and polyporata; R. laxa* must be referred to a different genus. As *Millepora*, Phillips described two species of *Ceriopora* in the Geology of Yorkshire, *Millepora rhombifera* and *interporosa*, and in the Palæozoic Fossils two others, *M. gracilis* and *similis*, which are more or less abundant in the Carboniferous formation. Two other species, *M. spicularis* and *M. oculata*, have been referred by Morris (Cat. of Brit. Foss.), to the genus *Pustulopera* Blainville. The *Retepora pluma* of Phillips belongs to at least two types of Polyzoa.

---

* Transactions of the Yorks. Geol. and Polytech. Soc., 1881.

As the whole of the Palæozoic Fenestellidæ * have received from Mr. G. W. Shrubsole very marked attention, I am saved the necessity of furnishing any elaborate details, especially in respect to the Carboniferous species. Previous to the labours of Mr. Shrubsole there were about twenty-six described *Fenestella*,—these have been reduced to about five typical forms, and the elaborate details given by the author in his two papers, cause my labours on this group to be a comparatively easy one. I shall, therefore, accept without unnecessary discussion, Mr. Shrubsole's work, adopt the specific characters he has given, and also the types restricted or received by him. I do not accept the whole of the synonyms, for the simple reason that I desire to keep before me the labours of Phillips. I do not doubt the accuracy of the synonyms, because I believe, generally speaking, that Mr. Shrubsole is right. There is one advantage to be derived from purely local work over that of the more general labours in the study of our British Palæozoic Polyzoa. In the local work we are compelled to direct particular attention to the types before us, because we find that whenever we recede from any life region there are divergencies, if not in the cell characters, at least in the habits of species which are worthy of much closer study than has yet been given to the subject. In the following pages I have described the specimens before me, and because of this I have not given the larger, and more general descriptions of Mr. Shrubsole which are founded upon a large suit of Carboniferous *Fenestella*, and from very wide localities.

---

* A Review of Brit. Carb. *Fenestellidæ*, Quart. Journ. Geol. Soc., May, 1879, further Notes *ibid* May, 1881.

Genus FENESTELLA, Lonsdale.

"*Zoarium*, a calcareous reticulate expansion, either flat, conical, or cup-shaped, formed of slender bifurcating branches (interstices), poriferous on one face, connected by non-poriferous bars (dissepiments), forming an open network. *Zoœcia* immersed in the branches and arranged in two longitudinal rows divided by a central 'superficial' keel, on which are often prominences. Orifice of Zoæcia small, circular, and prominent when preserved." (Carb. Fenestellidæ, G. W. S., p. 179 *Quart. Jour. Geol. Soc.*, May, 1881.

1. **FENESTELLA PLEBIA.** McCoy, Syn. *Carb. Fos.*, *Ireland*, p. 29, Fig. 3.
= *R. flustriformis*, Phillips, *Geol. Yorkshire*, pl. I., Figs. 11-12.
= *R. irregularis*, ,, ,, ,, ,, ,, 21-22.
= *R. undulata*, ,, ,, ,, ,, ,, 16-18.

Phillips' descriptions of these species are brief and unsatisfactory. Of the first, very few particulars are given: *R. irreuglaris* and *R. undulata* are different portions of the same species, and Mr. Shrubsole has done well in selecting the well-described *F. plebia*, McCoy, as the type of this group. In the Derbyshire specimen the Zoarium is a flat expansion, the dissepiments are thin, and the fenestrules are oval, with four or five zoæcia on each side, and only five fenestrules occupy the space of two lines measured transversely, four in the same space in a longitudinal direction. There is nothing in this that would interfere with typical *F. plebia*, other parts of the Zoarium would give different results. I have not the least doubt but that this is the typical *Retepora* and Millepora *flustriformis* of Phillips and Martin. Phillips' figure is that of a cast, and the same specimens show that the mere casts of the fenestrules would give in a drawing, precisely the same result as in Figs. 11 and 12. On another part of the Zoarium there is a thin crust of *Hemitrypa*, similar to that referred to in my previous paper *(Hurst and Richmond Polyzoa*, p. 335, 1881). The specimens of *F. plebia* from Settle are more in accord with the Welsh and Scotch examples of the type: the "fenestrules are equal, rectangular, from two to three times as long as wide."

Localities: Derbyshire, Castleton; Yorkshire, Settle. Widely distributed, and ranging from Lower Carboniferous to Permian.

2. Fenestella membranacea, Phillips' *Geol. Yorks.*, Pl. i., Figs. 1 to 6.
= *R. flabellata*, Phillips' *Geol. Yorks.*, Pl. i., Fig. 7-10.
= *R. tenuifila* „ „ „ „ 23-24-25.

I have only poor specimens of the type *R. flabellata*, Phillips; it is a portion of the flat expansion of the upper portion of the Zoarium. The branches are rounded straight and in parallel lines; the dissepiments are fine, fenestrules oblong, slightly wider than the branches, and the average number to two lines, are about eight transversely, and five longitudinally. The Zoæcia are small and the orifice circular, from three to four occupy the length of the fenestrule.

Some very interesting particulars are given by Mr. Shrubsole respecting the development of this species, and in all probability the whole of his synonyms are correct, but I am not able, for want of material, to endorse the whole.

Localities: Derbyshire, Castleton; (Phillips: Bolland, Harrogate, Richmond, Hawes, Whitewell, Middleham).

3. Fenestella nodulosa (?) Phillips. *Geol. Yorks.* pl. i., Figs. 31, 32, 33
= *F. Frutex (?)* McCoy *(Syn. Carb. Foss. Ireland*, pl. xviii., Fig. 10).

I have a fine specimen of *Fenestella* and it appears to me to be referable to *F. nodulosa;* and yet it might have very well served as the type of *F. hemispherica* McCoy. It is hemispherical and cup shaped, otherwise it is characteristically *F. nodulosa.* The Zoarium begins as a small base, enlarging and expanding by growth till at the distal part it is nearly two inches in breadth. The zoæcia open in the inside of the cup. In this respect it closely resembles the flabelliform growth of *F. frutex* McCoy, a name which Mr. Shrubsole gives as a Syn. of *F. nodulosa.* Although I have marked the species with a note of interrogation I have but little hesitency in accepting the character as given in the paper on Carboniferous Fenestellida, p. 183. In comparing, however, this with a Scotch specimen of *F. nodulosa* I cannot help remarking on the difference in the habit of the two types. The Derbyshire specimen is a deep water, and the Scotch a comparatively shallow water form, and in the first, the root, branches, and cells are strong and robust, whereof in the latter the whole framework is delicate or slender. Phillips' description appears to have been given from a flattened specimen. *Zoarium*, "Radiating dissepiments thin, fenestrules arcuato quadrate, pores usually one at the middle undulating the margin, and one at each dissepiment," the following refers to the remains of the spiny processes along the keel, "Smaller pores in the interstices."

Since this was written I have received from Mr. Aitken another fragment of *F. nodulosa* that might have served as the type of Fig. 31, pl. I., *(Geol. of Yorks.)* It is far more delicate and characteristic of the species than the above. With this specimen before me I am obliged to say that very few descriptions could be clearer than that given by Phillips, as already quoted, but I have no desire to remove the (?) from the above description.

Localities: (Phillips: Whitewell, Greenhow Hill, Harrogate).
Castleton, Derbyshire; Settle, Yorkshire.

4. Fenestella polyporata Phillips, *Geol. Yorks.* pl. i., Fig. 19, 20. *F. multiporata*, McCoy, *Syn. Carb. Foss. Ireland*, pl. xxviii, Flg. 9.

I have before me several specimens of this species, the largest of the British Fenestellidæ as regards the size of the fenestrules. Mr. Shrubsole who has had the advantage of comparing the type specimens of McCoy, or at least specimens from the same locality says—"It is subject to considerable variation." Prof. McCoy in his arrangement of the *Fenestella* assigned the smaller type to Phillips' *F. polyporata*, and the type with the larger development and greater number of pores he described as *F. multiporata*, but as both conform so well to the type in other respects, there is no reason for the division (Op. cit. p. 186.)

Zoarium foliaceous branches large and rounded, fenestrules large and elongated, four in the space of a line measured transversely, and two in the same space if measured longitudinally, keel rounded and well developed. *Zoœcia* from five to nine in the length of the fenestrule, openings small, occasionally prominent. Dissepiments, thin and placed at irregular distances.

Localities: The only locality given by Phillips is Florence Court. Castleton, Derbyshire; Poolvash, Isle of Man; (Small fragments) Settle, Yorkshire. These are the only species of *Fenestella* that I have any record of in West Yorkshire or Derbyshire.

With regard to *Fenestella flustriformis* as described by Martin, I have thought that the following quotation from the *Petrefacta Derbiensca*, Vol. I., Pl. 43–45, Figs. 1 and 2, and Fig. 3, may be valuable. It is the only Polyzoa figured or described in the work.

"ERISMATHOLITHUS MILLEPORITES? *(flustriformis).*

Plano-foliaceous, reticulatis, poris minutis, sub-obsolelis sparsis.

Fossil coral, originally a Millepora? Plano-foliaceous or flat, and thinly expanded like a leaf; its form or outline is uncertain. (Note.—All the specimens I have yet collected appear to be only fragments or portions of the original). Its fabric open and reticulated, somewhat resembling the coralline distinguished by the title of *flustræ.* The surface of the fibres forming the reticulation, roughened with minute, indistinct scattered pores; not, however, visible without the assistance of a magnifier. Common in Limestone, Middleton."

I am unable to identify Martin's species in the Limestone of Middleton from either the description or figures. Fragments of *F. plebia.* and *F. nodulosa* are common, and I see no reason to prevent me referring Martin's type to *F. plebia* McCoy.

Genus PTYLOPORA, McCoy.

Zoarium, a feather-like arrangement, having a central stem, which gives off lateral branches, which are connected by dissepiments; the branches very rarely bifurcate.

5. PTYLOPORA PHILLIPSIA. sp. nov.

Zoarium multiform.—Central stem bearing two rows of cells like the *Glauconome* species. Lateral branches striking off at acute angles from the main stem, are united by dissepiments, ultimately forming a cone-like zoarium. Zoæcia on the central stem, one between each of the branches, on the branches from two to three on each side of the fenestrule. Dissepiments strong, slightly dilated at the points of junction with the branches.

Locality: Castleton, Derbyshire. Rather abundant.

The peculiar habit of this species is so unique that I feel certain that it is not the *Ptylopora pluma* of McCoy. I have some doubts as to whether fragments of the cone-like zoarium have not been previously referred to *F. membranacea* as some resemblance exists between the two species if the central stem is absent in the fragment: otherwise there are few features in common between *Fenestella* and *Ptylopora*. The fragment named *Retepora pluma* by Phillips, must not be confounded with *Ptylopora pluma* McCoy. I have a specimen of the latter species from Malahide, and the species is very well figured in *Nicholson's Manual of Palæontology*, Vol. I., p. 423. Sometimes the fossil here described is present in the Limestone as casts only, it is then seen that the place in the zoarium which the central stem occupied is a long and central furrow, and the surrounding cast has some resemblance to a minute auger, and when seen for the first time, is likely to be a complete puzzle to the palæontologist. As the genus is a rare one, these minute particulars may be the means of drawing the attention of the student to special features, such as the apex and the base, which are not so well known.

6. PTYLOPORA PLUMA? McCoy. (Compare with Figs. 263, p. 422, *Manual of Palæontology, Nich.* vol I., with Fig. 9, p. 14, *Page's Introductory Text Book of Geology).*

I am not certain that this is really the *P. pluma* of McCoy, as the only portions of the Zoarium that I have are the central stem with some of the lateral branches. Accepting Nicholson's fig. as above I will now describe the fragments. Central stem (Glauconome like), the origin of the stem appears as a root-like prolongation divided into narrow prongs altogether unlike the stem in its after development; higher up rootlets appear on the sides, and higher still the normal character with lateral oblique fenestrations as in ordinary *Ptylopora*. Normal stem with a broad central rounded keel bearing in the sides a row of cells, alternately placed on either side of the keel—keel spinulose along the centre. Branches united by dissepiments which are rather broad in the junction; apparently destitute of keel. Fenestrules rather broad, slightly oval bearing on either side three cells,—openings circular. General shape and size of Zoarium unknown.

Locality.—Castlelon, Derbyshire.

There is a marked difference between this and *P. Phillipsia.*

1st.—The root-like base of the present species is, so far as I can see, unique. 2nd.—The strong rounded central keel with its spiniferous row is also different, in *P. Phillipsi* there is no prominent keel, the two rows of cells are in one plane, and whenever these are exposed, the bases of the cells are contiguous as in *Glauconome* species. I have purposely kept the two distinct, but the possession of better material may cause me to alter my opinion in the future. Under present circumstances it is impossible to do so.

Genus POLYPORA, McCoy.

7. POLYPORA LAXA, Phill., *Geol. York.*, Vol. I., pl. I., figs. 26-30. *(Retepora laxa*, pars.)

= *Fenestella laxa*, Phill. Palæoz., Foss. of Devon, Cornwall, &c.

= *Polypora laxa*, Morris, Cat. Brit. Foss.

"An irregular open network, interstices round, bearing on the reverse, oval spaces in quincunx, and interjacent lines of very minute pores. It resembles *Gorgonia ripisteria* Goldfuss." Such is Phillips' original description of *Retepora laxa* of Whitewell; but the description is far more applicable to the Derbyshire, than to the Yorkshire specimen. In the Palæozoic fossils of Devon, &c., Phillips referred a similar fossil to his Yorkshire species. In his Geology of Yorkshire, Phillips seems to have given figures of two different species, but I cannot make out distinctly what they are. I cannot believe that Phillips was entirely ignorant of the Derbyshire specimens, for his larger figures closely resembles that which is before me. I shall therefore describe the Derbyshire species as the nearest to the original of Phillips.

Zoarium, an open network with a very irregular habit. Root like base thick and prominent. *Branches*, round, rather more robust in its early, than in its later stages; bearing three rows of cells on the face, reverse striated. *Fenestrules*, large and irregular, from two to three, in two lines, measured transversely, dissepiments thin.

Localities: Survived from Devonian, Phillips; Carboniferous, Whitewell; Kildare, Ireland; Derbyshire, Castleton; Settle, Yorkshire; Richmond, Yorkshire.

8. POLYPORA TUBERCULATA?

In the general aspect, specimens of the Zoarium of this species, closely resemble the Scotch *Polypora tuberculata* Prout, and I am not certain that the British species is not identical with it. For the present it may be as well to retain them separate, because there are still some features in the Scotch that I have not as yet detected in the Derbyshire species. The general habit of the two is similar; the arrangement and character of the cells is the same; it is only in the superficial tubercles that there is a difference.

Localities : Castleton, Derbyshire; Settle and Richmond, Yorkshire.

Genus THAMNISCUS, King.

Branches free, round, frequently and regularly bifurcating; more or less in one plane; Zoæcia on one side, cells immersed, round, arranged in oblique lines.

9. THAMNISCUS DUBIUS? King, *Permian Foss.*, p. 44, pl. V. *T. dubius*, (Shrubsole) Paper on *Thamniscus, Quart. Jour. Geol. Soc.* August, 1882.

Var. *Carbonarius*, new var.

Zoarium, a series of flattened branches generally in one plane. Branches free, frequently dividing, measuring about half a line in breadth, equal in size along their whole length. *Zoœcia* on one side of the branch, apertures circular arranged in lines, or obliquely; about six cells in one line measured longitudinally, from four to six rows in the width of branch.

Localities: Castleton, Derbyshire; Settle, Yorkshire (small fragments).

There is a very great difference between the above species and that described by Mr. John Young, as occuring in the Carboniferous rocks of Scotland. *Thamniscus? Rankini*, Young (Ann. Mag. Nat. Hist., May 1875), is of uncertain affinities; for as Mr. Young remarks "Meanwhile though strongly disposed to regard this fossil as a true *Hornera*, or a member of a closely allied genus, we think it safer to leave it in the Palæozoic genus *Thamniscus*." The Scotch type may be ultimately placed in the genus *Hornera*; but the present form has not the least affinity with that or any genus related to *Hornera*. I have named the species as a variety of *T. dubius* out of deference to Mr. G. W. Shrubsole, whose paper on *Thamniscus*, Silurian, Carboniferous and Permian (*Quart. Jour. Geol. Soc.*, Aug. 1882), merits this special approval. In that paper the whole history of King's types is recorded, and a fresh description of *T. dubius* is given, after a careful comparison of the Permian specimens in the Newcastle Museum.

The Derbyshire species is comparatively rare, but I have been singularly fortunate in the fragments given to me by Mr. Aitken. I have both the reverse and the obverse, and besides this, there are several smaller fragments which afford good diagnostic characters. In founding the Genus *Thamniscus* Prof. King says " It embraces the two following genera, one of which *(Thamniscus)* is the type, and apparently Mr. McCoy's *Ichthyorachis. (Permian Foss.* p. 43.*)*

The following is McCoy's description of this genus :—

Genus ICHTHYORACHIS, McCoy.

A straight central stem, having on each side a row of simple branches or pinnæ, all in the same plane, obverse rounded, without keel, *each bearing* several rows of small prominent oval pores, arranged in quincunx, reverse smooth, or finely striated. (Carb. Foss.)

The only species *I. newenhami*, McCoy, County Clare, Ireland.

The type of this genus appears to correspond more closely as an ally of *Glauconome* than *Thamniscus*, yet there are specimens amongst my Derbyshire collections that seem to reconcile the apparent conflict of opinions, but I do not think we shall be able to maintain McCoy's genus as a separate type. I will endeavour to describe fairly the two types and leave the reader to judge.

10. ICHTHYORACHIS, s.p.

Zoarium in its earlier stages, a strong central stem with lateral pinnæ. These do not strike off at right or acute angles like *Glauconome* but the pinnæ bifurcate as free branches, rather diminutive at first, but towards the apex of the branches as bold and unfenestrated twigs. In the earlier stage the cells are arranged on the surface of the stem in three rows, on the pinnæ in two rows, and on the terminal free branches in from two to three rows.

In a small fragment of another, or the true *Thamniscus* type, casts of the main stem remain with a few lateral depressions. A small poriferous portion still remaining in one of the furrows, show that the arrangement of, and character of the cells are similar to the variety already described. In the absence of better material I must leave the species as somewhat doubtful.

Locality: Castleton, Derbyshire.

Genus GLAUCONOME, Goldfuss.

(See paper by G. R. V. on Carb. Polyzoa, North Yorkshire, Trans. Geol. and Polytech. Soc., 1881).*

If we except *Retepora pluma*, which has yet to be worked out, no *Glauconome* was described by Phillips in his *Geol. of Yorks.* In his *Palæozoic Foss.*, a species which is described as occuring in the Upper Devonian, is named *G. bipinnata*, and McCoy in describing a similar species from the Carboniferous Limestone, Dungannon, furnishes us with a few particulars respecting his type. It appears to me that Phillips' species was founded upon a peculiar habit, if so, this species is not unique in its *bipinnate* arrangements. Mr. John Young, of Glasgow, writing me about English and Irish *Glauconome*, says (Oct. 1877) "We seem to have no *Glauconome* in Scotland answering to the description of *G. grandis*, and *G. gracilis*, McCoy, although both have been noted in former lists from our beds. McCoy states that *G. grandis* has very small round prominent pores, one at the origin at each branch and three between. *G. gracilis* is said to have in each side a row of very large circular prominent pores which strongly indent the margin, one at the origin of each branch and one between, and about half the diameter apart. After very close examination of all our specimens, I have never found a fragment agreeing with either of the above species. I am inclined to think that we have only one species that agrees with any of McCoy's description, that is *G. bipinnata*, Phillips. In the shales from Capelrig we find a form with a straight crenated keel, or midrib, that has an oval pore at each branch and one between, reverse strongly granulated. McCoy does not mention anything about the keel in his description, he only says 'obverse with two rows of approximate oval pores, reverse with strong granulated striæ.' If it can be shown that *G. bipinnata* is not keeled in the typical form from

---

* In my fourth British Association Report on Fossil Polyzoa, 1883, I have altered—for reasons there given,—the generic name *Glauconome*, for that of *Pinnatopora*. As this paper, however, was written and read before the change was made, I have allowed the references to stand. I reserve the Genus *Glauconome* Goldfuss for Silurian specimens only.

England or Ireland, then the Scotch species is new, but rather than make it such, in the meantime I shall leave it as it is, and distinguish it as *G. bipinnata?* Phillips." After this letter was written Mr. Young sent me specimens of this species, and I shall use it in making my comparison with the Derbyshire fossil.

11. GLAUCONOME BIPINNATA? Phillips. Palæozoic Fossils of Devon, &c.

Zoarium, a long stem which branches rather acutely at distances about four lines apart; in the intervals of the larger branches, smaller pinnæ, four to a line, are placed alternately on each side of the main stem. *Zoœcia* on the main stem, orifices oval, two in the intervals of the small pinnæ, or about eight to a line on each side of a not very prominent mid-rib; cells on the branches similar to the main stem; cells on the pinnæ rather smaller, and more closely set. Reverse striated, or slightly granulated.

Localities: Upper Devonian, Pilton, Croyd; Castleton, Derbyshire; Ireland, (McCoy), Blantyre? and Capelrig? Scotland. The *Glauconome* of Settle, Yorkshire, is not in a sufficiently good state of preservation to allow me to describe the species.

In the Carboniferous Limestone of Derbyshire there are several varieties of this peculiar type, one of which possesses a very strong main stem, pinnate and bi-pinnate as already described. I cannot, however, regard it as a distinct species, the only additional character is its robustness. The arrangement of the cells are similar. I can only suppose that this additional feature is the result of age.

A reference to my former paper will show directly, the difference between the character and abundance of Glauconome in North Yorkshire and in Derbyshire. For a long time I regarded the *Retepora pluma* of Phillips (*Geol. York.* pl. I., fig. 14-15) as a *Glauconome*, but the careful working of the type seems to dispel this idea. In all probability fig. 13, pl. I., *Geol. York.* is the reverse of *G. bipinnata?* Phillips, but it is hard to say.

Genus RHABDOMESON, Young.

Ann. Mag. Nat. Hist., January, 1874.

12. RHABDOMESON GRACILIS, Phillips sp. Palæozoic Fossils, Devon, &c. (See North Yorkshire Polyzoa by G. R. V, Trans. op. cit).

I have only detected a few fragments of this species in the Derbyshire Limestone specimens. The species has a very wide range.

Localities: Devonian. Pilton (Phillips), Castleton; Hurst, Richmond, Yorkshire; Scotland, very generally distributed; Northumberland.

There are still remaining a few doubtful species, in my own, and in Mr. Aitken's collection. I cannot work these into the present paper for they are without a local habitation, and the fragments are not in such a state of preservation as to allow me to do them justice.

Now that attention has been directed to the Polyzoa of Derbyshire and North Yorkshire it is to be hoped that in the coming season for geological excursions some little attention will be given to the presence of these as well as to other, probably, more attractive groups of fossil remains.

ON THE GEOLOGY OF PALESTINE. BY W. H. HUDLESTON, M.A., F.G.S., &c.

In the original choice of the subject, two principal considerations influenced me. In the first place, there is no foreign country whose history and geography attract more attention from all classes than does the Holy Land. It seemed therefore certain that a previous geographical acquaintance with the region might induce some curiosity as to its geological structure. And this brings me to the second consideration, which influenced my choice of a subject, viz., that Palestine—using the term in its widest geographical sense—contains within its borders some of the most remarkable features on the surface of the earth; and, notably, that astounding fissure, the Dead Sea Basin, which probably has exercised the imagination of most of us for a long period, and which geology, of all the sciences, is the most competent to investigate.

To facilitate reference, the subject has been divided into eight sections, as follows:—

1.—History of the Investigation of the Region.
2.—Physical Geography.
3.—Geological Outline and Explanation of the Map.
4.—Beds older than the Cretacous Limestone.
5.—The Cretacous and Nummulitic Limestones.
6.—Post-nummulitic (Marine) Beds.
7.—Volcanic Rocks.
8.—Deposits of the Dead Sea Basin.

1. *History of the investigation of the Region.*—This branch of the enquiry is by no means devoid of interest, and might almost form a subject of itself, independent of the others. Of course we could go back as far as the days of the Crusades, for even then the fossil fish of the Lebanon were not unknown, since Richard Cœur de Lion is said to have noticed them; but for our purpose it will suffice to begin with the present century.

What we must now term the first occupation of Egypt by the British forces, in the early part of the present century, drew particular attention to the East, but such was the disturbed state of affairs during the period of the revolutionary wars that travelling was for the most part suspended, though some of the Royal Engineers about this time made short surveys in portions of Palestine. It is evident, however, that the occupation of Egypt had drawn attention to the East, for there was a meeting held of the *Palestine Association*, as it was then called, on the 24th of April, 1805. What they did is not known to me, though there is a tradition that agents were sent out, who got no further than Malta. Anyhow no active steps were taken by this body after the year 1809, and the Association may be deemed to have led a suspended existence up to 28th January, 1834, when a meeting was called, Mr. Bartle Frere in the chair, which resulted in the balance of its funds, amounting to £135 9s. 8d., being handed over to the *Royal Geographical Society*, and the original *Palestine Association* was, I presume, thenceforth regarded as defunct. But this is anticipating: we must now revert to an earlier date. At the close of the great war there was an immense increase of travelling all over the world, and the East very naturally came in for its share. Some of you are perhaps acquainted with the interesting narrative of Irby and Mangles, and with the classical work of Burkhardt, which, together with others published before 1830, laid the foundation of our physical knowledge of Sinai and Palestine.

Geology in those days was quite in its infancy, yet Burkhardt had an eye in that direction. But the first really geological work was one by Botta, entitled *Observations on Lebanon and Anti-Lebanon*, published in the Memoirs of the Geological Society of France, in the year 1833. So that France led the way to geological research in Syria, and that lead she has since fully maintained.

I must now say a word about an important discovery. This was no less than a recognition of the singular physical fact, that the Dead Sea Basin, for a length of 200 miles, lies at a considerable depth below the level of the sea. Not only were the writers of antiquity ignorant of this peculiar feature, but it had also escaped the notice of Burkhardt and the earlier travellers, so that five and forty years ago, the whole world, scientific and unscientific, were quite ignorant of it. Like many great discoveries, it seems to have dawned upon several people nearly about the same time. It is not easy to assign the credit of the first discovery, but in the year 1837, two Englishmen, Messrs. Moore and Beck, published an account in the journal of the *Royal Geographical Society*. There was a considerable difference then and subsequently, as to the actual amount of the depression,—but to anticipate, I may say that the Surveyors of the *Palestine Exploration Fund* have fixed the level of the Dead Sea surface at 1,292ft. That was a time of general activity in the way of Palestine research, as the well-known work of Dr. Robinson appeared in the following year,—viz. in 1838,—and it was at this period also, that the Austrian mining engineer, Russegger, travelled, though his work was not published until ten years afterwards.

Encouraged by the success of their learned fellow-countryman, Dr. Robinson, the Americans entered into the investigation with great zeal, and the decade between 1840 and 1850 witnessed some important contributions from them. American missionaries have generally been observant men; some of them in Syria had made certain notes and collections of specimens, and these were submitted to Professor Hitchcock, who wrote a most important paper, so valuable indeed, that M. Lartet says, that Hitchcock, although never there, had a far better idea of the geology of Palestine than the majority of travellers, whether before or since his time; but then Hitchcock is a geologist, whilst the majority of travellers are not.

The efforts of the Americans culminated in the expedition undertaken by Lt. Lynch, in 1848, with Dr. Anderson as geologist. The party launched a couple of metal boats on the Lake of Tiberias, and after an exciting and hazardous voyage down the Jordan, reached the Dead Sea in safety. Considerable difficulties were experienced, owing to the shallows, and to the tortuous character of the river, which describes a course of 200 miles, when the actual distance is 65 in a straight line. The Jordan was probably then navigated for the first time, though the *Rob Roy* canoe afterwards, I believe, ventured upon its waters. A very efficient investigation of the Dead Sea was made, and the leading physical features of the great fissure, known as the Ghor, ascertained beyond question. It was at the same time proved that even the weird and unwholesome nature of the place, in addition to Arab troubles, could not prevent a well-led and devoted party from doing its work effectually. Lynch's men were, I believe, all total abstainers. A large collection of fossils was made by Dr. Anderson, and many of these were described and figured in the fine quarto which recorded the results of the expedition.

After this adventurous journey there was a lull for some time in Palestine exploration: the cream of the mystery had been solved, though as yet but little real progress had been made in geology. But in the next decade renewed attention was paid to the subject, and two works appeared, which may be said to have placed the geology of Palestine on a firm basis. These were *Aus dem Orient*, by Dr. Oscar Fraas, and *La Géologie de la Palestine* by M. Louis Lartet. These authors have published other works on the subject, but I mention the above, as being amongst their most important contributions. Lartet's book was the outcome of his experiences as geologist to the celebrated expedition of the *Duc de Luynes*, undertaken in 1864, and which has been more fruitful in geological information than any other. The party commenced their investigations in the Lebanon, and thence passed by way of Samaria and Galilee to Jerusalem; then on to the Dead Sea, where they embarked on board the iron vessel, *Ségor*. Their examination of the Dead Sea was most thorough, methods being adopted for obtaining the water from various depths for analysis, anticipating as it seems in some respects those used by the *Challenger*. The party then ascended the right bank of the Jordan, about half-way to the Lake of Tiberias, returning by the left bank, and so along the east side of the Dead Sea, through the mountains of Ammon and of Moab, which they were the first to examine from a scientific point of view. A second visit was made to Jerusalem, whence they again started by way of the mountains of Judæa for the Dead Sea, and so up the Wady Arabah into the Petra district, and thence over the watershed between the Wadies Arabah and Akabah, and down to the head of the gulf. It may be safely said that no observer ever brought away with him such an important mass of geological information respecting these difficult countries as did M. Lartet. In fact, it would be needless to say more of this particular journey at present, as the results form the basis of this communication.

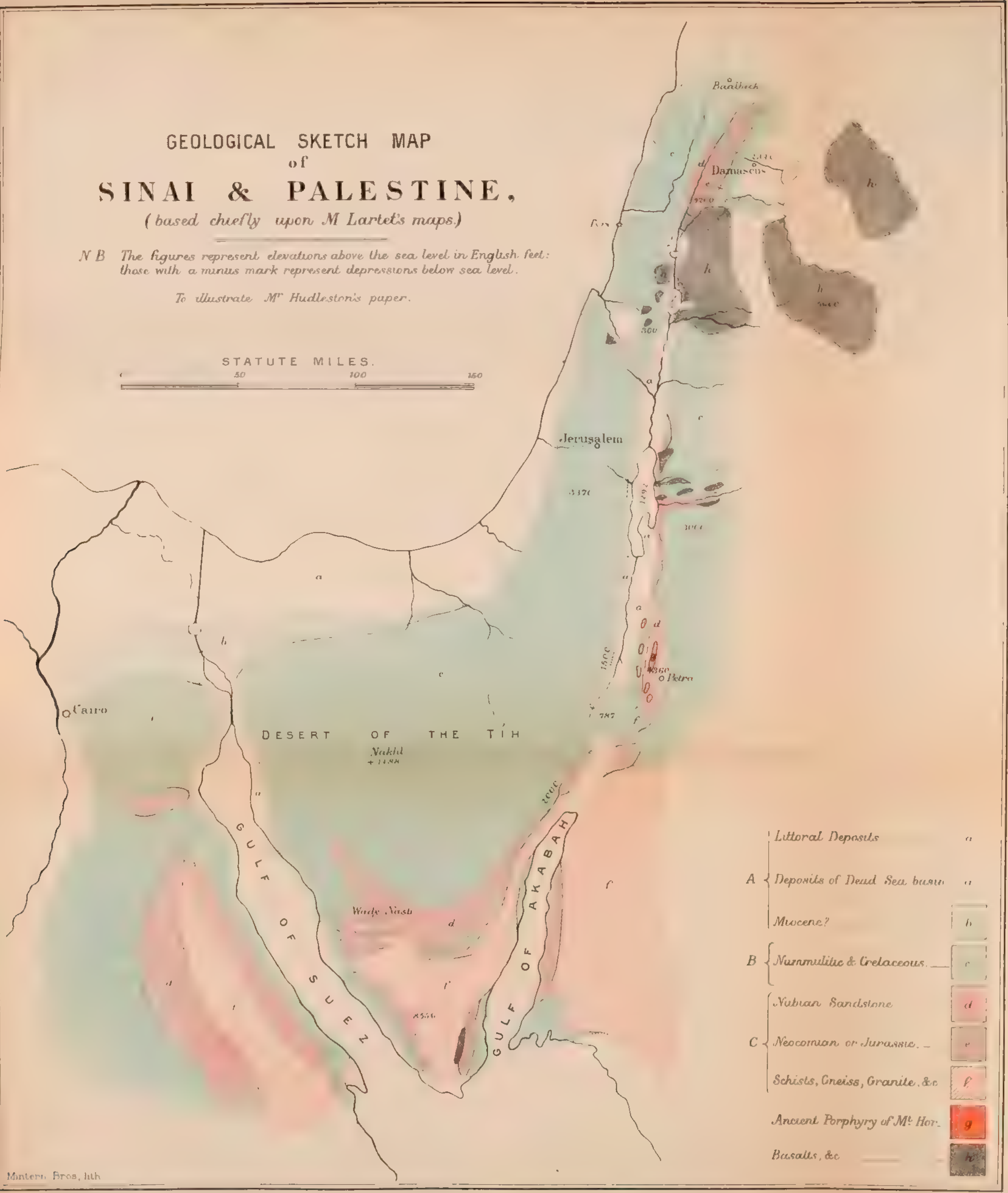
About the same period, some good work was done rather outside the Palestine area, and chiefly in the Sinai district, by some of our own fellow-countrymen. I would especially mention the papers by Messrs. Duncan, Carter and Holland, in the *Quarterly Journal of the Geological Society*, and very important papers by Mr. Bauerman and Professor J. Milne. Mr. Bauerman's paper is by far the most valuable contribution we possess relative to the mining districts of the Sinai Peninsula.

We now come to the *Palestine Exploration Fund*, which was founded in 1865, "for the purpose of elucidating and illustrating the Bible, by a systematic survey of the Holy Land, by excavations, by the collection of traditions, manners and customs of the people, and by researches into the natural history, meteorology, and geology of the country." In the *Quarterly Statement* for 1869, it is remarked "Of this (*i.e.* of geology) we are in ignorance in almost every detail; the valley of the Jordan (and basin of the Dead Sea) is geologically one of the most remarkable on the earth's surface."

It is impossible to speak too highly of the topographical work of the survey, but somehow, very little geological work has been done, though there are papers by Captain Conder, which show that the subject possessed considerable attraction for him. His Physical description of the Holy Land,* and his chapter on the Jordan

---

* Tent Work in Palestine.



GEOLOGICAL SKETCH MAP of SINAI & PALESTINE,

(based chiefly upon M Lartet's maps.)

N B The figures represent elevations above the sea level in English feet: those with a minus mark represent depressions below sea level.

To illustrate Mr Hudleston's paper.

Mintern Bros, lith

valley,* should be read by everyone desirous of becoming acquainted with the geognosy of these regions. The one-inch map of Western Palestine was published by the Committee of the *Exploration Fund*, in 1880, and there is a very useful reduction, together with sections executed by Mr. Trelauney Saunders. Fig. 1 is a reduction from a meridional section constructed by him. I ought to mention here also the Ordnance Survey of the Peninsula of Sinai, undertaken in 1868–9, of which a most interesting account is given by the late Professor Palmer, in the first volume of the *Desert of the Exodus.*

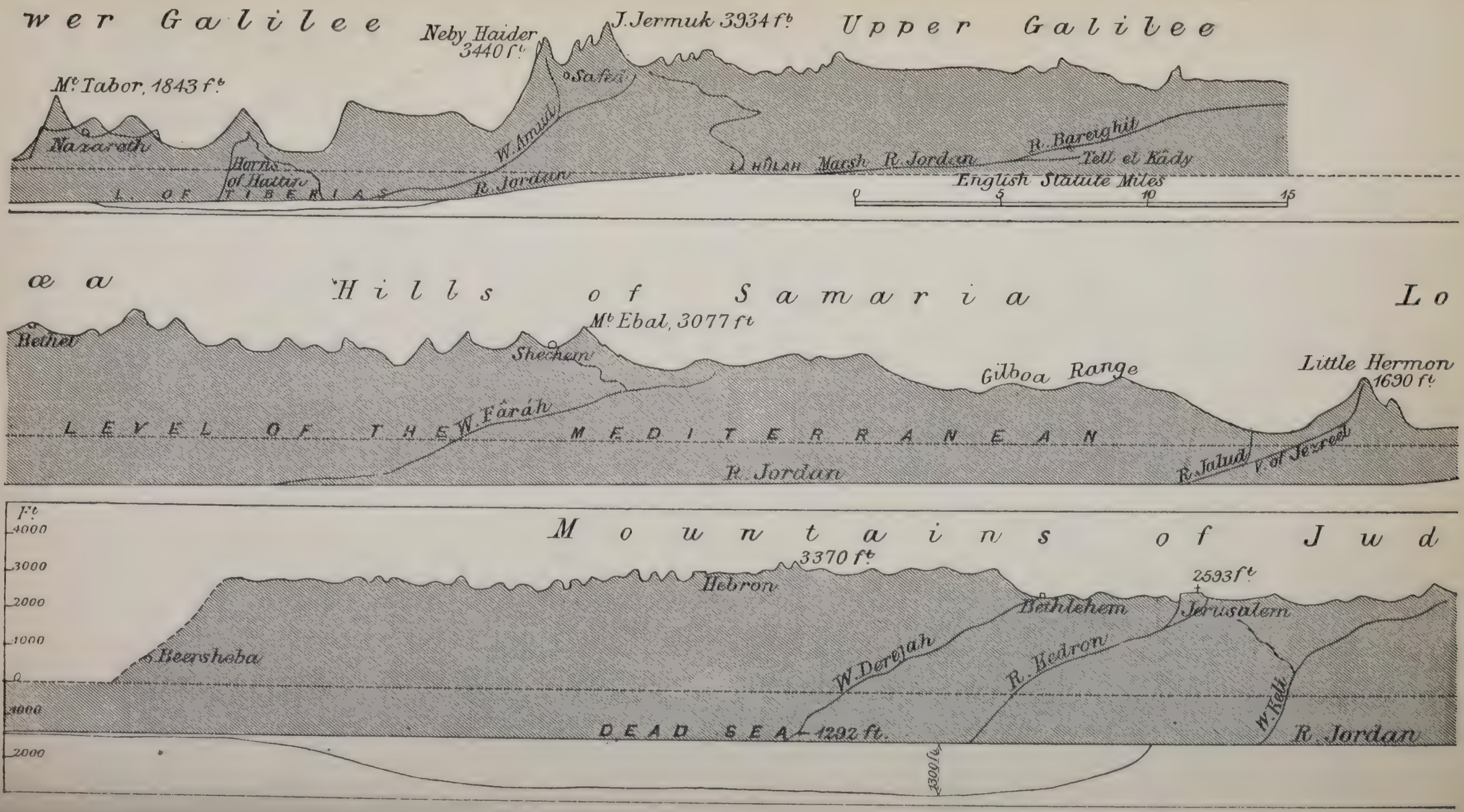
Though scarcely geological, the admirable volume of the late Dean Stanley, and the adventurous narratives of Canon Tristram contain much geognostic information, and as they are well illustrated and ably and pleasantly written, these works have always been in great favour with the English public. In concluding this part of the subject, I may remark that as far back as the year 1867, no less than eighteen hundred and sixty works were enumerated on the subject of Palestine, and they have increased portentously since then. It is true, that very few of these contain the smallest item of geological information, yet much has to be read in order to pick up the scanty morsels. The importance of M. Lartet's works cannot be over-estimated.

2. *Physical Geography.*—It will be necessary to consider the geography before attacking the geology. According to Captain Conder, the limits originally assigned by Moses to the Holy Land extended from Mount Hor on the *south*, to the water-parting of the two great Lebanon rivers, Orontes and Leontes, on the *north;* and from the Mediterranean on the *west;* in the direction of the Euphrates on the *east.* For our proposes we must exceed these limits on the south, so as to include the whole of the peninsula of Sinai. Without attempting to give it a general name, we shall take into consideration the whole country, from, say Baalbec, which is very near the aforesaid water-parting, to the most southerly part of the peninsula of Sinai; the western boundary will be the Gulf of Suez, and the line of the canal; the eastern boundary stretches towards

---

* Hand Book to the Bible.

Fig. 1. Meridional Section of Western Palestine. (Reduced from Mr. Trelawney Saunders' section by W.H.H.)



the Arabian desert.

In order to give some idea of distances, and by consequence of relative size, let us commence at the foot of Mount Hermon, which must be regarded as the parent of the Jordan, and the great condenser of moisture in those regions.

	MILES.
Foot of Hermon to the Lake of Tiberias	28
Lake of Tiberias, length	12
Jordan Valley	65
Dead Sea, length	46
Dead Sea to Gulf of Akabah	114
Head of Gulf of Akabah to Jebel Mousa	105
	370

Again, the width of lower Galilee, from Acre to the Lake of Tiberias is about thirty miles, whilst the width of Judæa from the Mediterranean to the Dead Sea is about fifty miles.

Palestine, as we usually understand it, is an upland plateau, split longitudinally by the *crevasse* of the Dead Sea Basin, and it lies between the great limestone ranges of Lebanon and Anti-Lebanon (including Hermon) on the north, and the almost equally lofty granitic ranges of Sinai on the south. Lebanon and Anti-Lebanon roll over in a series of convolutions, but nowhere, according to recent survey, is there so high a point as Hermon, which must be regarded as the monarch of the region, with an elevation of 9,200ft. Hermon is the southern termination of the range of Anti-Lebanon, and looks down upon the mountains of upper Galilee, which barely attain to half its elevation. The volcanic mass of Jebel Kuleib, the hill of Bashan, attains an elevation of 5,600ft., but south of this, there are not many points over 3,000ft. on either side of the Jordan, till we come to Mount Hor, 4,360ft. Between this and the gulf of Akabah, are some lofty hills, one of which is the Sinai of Dr. Beke. There is one feature to which I would particularly draw attention, and that is to the very considerable watershed which exists between the Wady Arabah and the Wady Akabah.

The country west of the Wady Arabah is usually known as the Negeb, or south country, and was part of the "Land of Promise;" south of this again is a most terrible country known as the Desert of the Tih, a limestone plateau, whose central point is marked in the maps as 1,480ft This is about half way between Suez and Akabah, and is the place for which the late Professor Palmer was making when he was murdered.

A remarkable limestone escarpment forms the termination of the desert of the Tih, wedging itself into the Sinai Peninsula. The Negeb or south country, wedges itself into the Tih in a similar manner. In the Sinai Peninsula the mountains again become very lofty, and there are three granite ranges which especially claim attention: on the west is Jebel Serbal; in the centre is the Sinai group, culminating in Jebel Katarina, the highest peak in the peninsula, 8,536ft.; on the south is the peak of Um Shomer, for a long time regarded as the highest of all. These lofty mountains of the Sinai Peninsula constitute the central section of the tripartite granitic region, which is severed by the gulfs of Suez and of Akabah.

Let us now direct our attention to the topography of western Palestine, since this has been surveyed with great accuracy (see Figure 1) which affords a meridional section of the whole country, I might say, from Dan unto Beersheba. In this section the upper sinuous line represents the watershed of western Palestine, between the Mediterranean and the Jordan valley; the middle line represented the level of the Mediterranean, and the lower line the course of the river Jordan. In sections of this kind the difference between the vertical and horizontal scales produces a false estimate of the abruptness of the slopes. Bearing this in mind, the section is an instructive one, though perhaps it requires a little reflection to understand.

The great basaltic mountains near Safed attain an elevation, as I before said, about half the height of Hermon: north-east of this great mass, lies the basin of the Hûleh marshes, which may be regarded as the *first* section of the Jordan valley system. In this marshy hollow the four rivers which form the Jordan unite, and open out into the waters of Merom or Lake Hûleh, whose surface may be regarded as nearly on a level with the Mediterranean. The great drop in the chasm of the Jordan valley occurs between Lake Hûleh and the lake of Tiberias, the fall being at the rate of 68ft.

per mile. This fall takes place between the volcanic masses of Safed and the Jaulan.

The *second* section of the valley includes the basin of the Lake of Tiberias, twelve and a half miles long, eight miles wide, and one hundred and fifty feet deep. There is a very great lessening in the height of the watershed opposite this basin, as though Lower Galilee had been let down bodily. The hills, though famous in history are amongst the most moderate elevations of the country.

The *third* section includes the gorge of the Kaukab, opposite Mount Tabor and Little Hermon, where there is another sharp drop.

The *fourth* section includes the Plain of Beisan, which connects by way of the Vale of Jezreel with the Plain of Esdraelon over a watershed, which cannot exceed 300ft., and which is therefore considerably lower than the watershed between the Wadies Arabah and Akabah. Indeed if the whole country were lowered between 300 and 400ft., perhaps rather less, the waters of the Mediterranean would flow into the great depression of the Dead Sea basin and fill it up, leaving still 300ft. before those of the Red Sea could meet them. The Vale of Jezreel is probably one of the most desirable and well-watered portions of the country, and fertile, like the Vale of Esdraelon, on the other side of the watershed. It might be tedious to detail the remaining four sections into which Captain Conder divides the Jordan valley. I will merely point out that it receives a considerable affluent from the west in the perennial stream that flows down the Wady Fârâh, which, there is reason to think, may follow the line of some important dislocation, and, at all events marks a great change in the character of the country. The Wady Kelt flows into the Jordan through the Plain of Jericho, and there are many salt springs throughout this part of its course.

The shape of the basin of the Dead Sea may be gathered from the section. (Fig. 1). An extreme depth of 1,300ft. is marked, though this is a little in excess of any on M. Lartet's map. The southern end is quite shallow for many miles, so that the actual basin of the Dead Sea now occupied by deep water is less than one would suppose.

I would direct your attention for a moment to the watershed which, if you were to trace it on the map, is pretty nearly equidistant, sometimes inclining towards the Mediterranean and sometimes towards the Jordan. It is not a little singular, how many places of interest are situated on, or close to the watershed—Nazareth, Shechem, Bethel, Jerusalem, Bethlehem, Hebron, illustrate the fact. Leaving the plains and moderate hills of Lower Galilee, we rise through the hills of Samaria to the Mountains of Judæa, and as over 1,000ft. has to be added to their height above the sea, the Mountains of Judæa show a massive section on the east side, the brow of the cliff or escarpment, overhanging the Dead Sea, being something like 2,000ft. above the great depression.

Now this great mountain group of Judæa is a natural fortress, and has been held for ages by a proud and determined race of highlanders, who had great contempt and hatred for such lowlanders as the Philistines. In after times the plateau was held by Saladin, whilst Richard overran the lowland plains. The plateau of limestone resembles very much the limestone pavements of Craven.

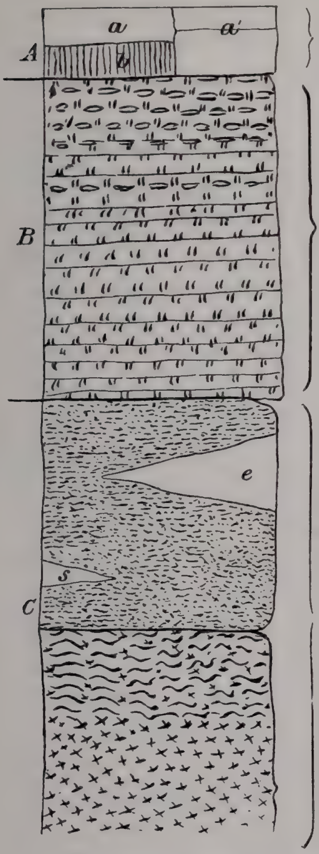
The physical geography of western Palestine would be incomplete without a word about the maritime plains. There is a strip of low sandy land all along the Mediterranean shore. In Phenicia, this is very narrow, and sometimes cut off altogether, as where the ladder of Tyre protrudes into the sea, and also where the still more conspicuous Mount Carmel makes a solid headland, the highest part of the block being 1,700ft. The Plain of Esdraelon is an inland plain, averaging between 200 and 300ft. in elevation, and covered with a rich basaltic loam; we have already seen that this is on a line of sinking in connection with the Vale of Jezreel. By all accounts, it is the most fruitful district in Palestine.

South of Carmel, along the coast, the maritime plain gradually widens, until the plain of Sharon merges into the wide expanse of Philistia. This is continued all the way to El-Arish, on the River of Egypt, though the boundary of Palestine proper may perhaps be regarded as on the Beersheba stream. In this portion of the maritime plain, Nile mud mingles with the drift sand, and further inland much of this is covered by the *debris* from the mountains. The dimensions are, 80 miles long, and near Gaza, 20 miles wide; 100–200ft. high.

3. *Explanation of the Map and Geological Column.*—"Geological Sketch Map of Sinai and Palestine." (Plate VI).

We must now turn our attention to the geology of the district, and by way of preface, I will give a brief geological demonstration of the map and vertical column (Fig. 2).

FIG. 2.



A.—(*a*) Coast deposits of probably quaternary age; (*a′*) Jordan valley deposits of two kinds; (*b*)? Miocene.

B.—Nummulitic and Cretaceous Limestones and Marls.

C.—The upper portion denotes the Nubian Sandstone, which is made to include the *Glandarius*-limestone and Jurassic rocks of the Lebanon (*e* of the map and vertical section); as also the limestone with carboniferous fossils of the Wady Nasb in the Sinaitic peninsula (*s* of the vertical section).

The lower portion includes the Schists, Gneiss, and Granite.

The use of a vertical column in geology is very considerable, as it enables people to see at a glance what they have to expect. At the same time it must be understood that no such section as is exhibited by this generalized column is ever seen in one place. In the map the *crystalline rocks* are all placed under the symbol *f*, and this includes the schists, gneiss and granite, which form the nucleus of three mountainous masses, viz.: the Arabian chain (in Egypt), the Sinai Peninsula, and the mainland of Arabia. The crystalline rocks are continued in the Mount Seir range, and probably re-appear in the ancient porphyry of Mount Hor. It is quite possible that these three granitic areas may have formed one continuous mass, as doubtless they still do beneath the surface. At present, as probably for many ages past, they are separated by that curious bifurcation of the Red Sea, which produces the broad and shallow Gulf of Suez, and the deep and narrow Gulf of Akabah.

The next formation, or rather group of formations, is the *Nubian Sandstone,* which has an extensive development in connection with the granitic centres, from whose degradation it has in times past been largely derived. It is most extensively developed in the north of the Sinai Peninsula, where the upland plain of Ramlah is interposed between the chalky desert of the Tih, and the rugged mountains of Sinai. Thence it may be traced all along the east side of the Arabah, through Petra, to the eastern cliffs of the Dead Sea, and even up to the Jordan valley, half way to the Jabbok, where it disappears and is not seen again until we arrive at the great hollow between Lebanon and Anti-Lebanon, which is a continuation of the Jordan depression.

The age of the Nubian Sandstone as a formation, is a difficulty which we shall appreciate in coming to study it in detail. Meantime, for us, it represents everything between the crystalline schists, and the Cretaceous beds. The meaning of these two wedge-shaped masses, *s* and *e*, in the vertical section, Fig. 2, I will explain presently. Now consider for a moment what a variety of rocks there are in our own country, between the crystalline schists and the base of the chalk. There is the Cambrian, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic and Neocomian. This shows the fundamental difference between the geology of England and of Palestine. Can the Nubian Sandstone represent all these? Surely not,—yet it may well represent more than one of the great systems in time.

Next in order and far more extensive are the *Cretaceous* and *Nummulitic Limestones*, which occupy such a large area in the map, and constitute indeed, the entire mass of the Palestine hills, of the Negeb, or south country, and of the terrible desert of the Tih. They are classed together, because of their physical unity, as one great calcareo-siliceous formation. Indeed the only test of difference is the presence of true nummulites. Now there can be no doubt that in Egypt, large portions of the area coloured blue on the map are nummulitic limestones; and also that a considerable portion of the western escarpment of the Tih is nummulitic chalk with flints; there is also a limited area near the head of Wady Akabah. The only localities known to yield nummulites in Palestine proper are the Mountains Ebal and Gerizim, in Samaria; and Mount Carmel, on the coast. There is also a small exposure of nummulitic limestone in Phenicia. Beds of Cretaceous age are largely developed in the Lebanon.

With respect to the portion of the map and section described as Miocene, there is some doubt. All the evidence goes to show that beds usually called "Miocene," were cut through in the southern portion of the Suez Canal, but how far these extend is by no means clear. Of course no great accuracy is claimed for the map in this respect. There is a quantity of flint breccia, the result of the breaking up of the Nummulo-cretaceous series, scattered about in different parts; some of which may be of Miocene age. In one place, near the Gulf of Suez, this was found to be associated with corals of a Miocene type.

The Deposits of the Dead Sea Basin include everything in the long fissure from the foot of Hermon to beyond the roots of Mount Hor. All we can say of them is that they are post-nummulitic, and the same may also be said as regards the *Lavas*, which are so abundant in the north.

The Coast deposits, marked *a*, are regarded for the most part as Quaternary and Recent; they are said to contain shell limestones, much used for building the cities on the Mediterranean; the shells being all those of recent species.

Since the Cretaceous limestones are by far the most important rocks in the country, they have a section to themselves, No. 5. The whole of the rocks below them are detailed under section 4, and those above them in section 6.

4. *Rocks older than the Cretaceous Limestones.*—We must of course begin with the crystalline rocks, of which granite is the most important, but with it are associated those porphyries, which in the Egyptian granitic region have yielded such fine building stones.

The mountainous core of the Sinai Peninsula, including all the great ranges before mentioned, consist of some variety of granite, and it is evident that red felspar granites are the most abundant, and characterize the region by the colour which they impart to the rocks. We obtain our best account of the physical aspect of this region, and of the peculiar features produced by granite and its associated rocks from the pen of the late Professor Palmer.*

This lamented author ascended most of the principal granite mountains, such as Jebel Mousa, Jebel Katherina, &c., and brought away specimens of the rocks; some of which by the kindness of Professor Bonney I have been able to inspect.

Rock Specimen 1.—Let us begin with the summit of Jebel Katherina. This is a *syenitic granite* of a peculiar nature: in a pinkish felspar base, which occupies the bulk of the mass, are small crystals of orthoclase, quartz, and hornblende. The quartz is not insterstial as in the more typical granites.

Rock Specimen 2.—Jebel Musa. This is from Mount Sinai itself, and is a mixture of coarse red felspar and grey vitreous quartz. There is very little trace of any third mineral, so that the rock nearly approaches a pegmatite.

Rock Specimen 3.—Summit of Serbal. This is a more thorough pegmatite than the other, and in better condition; the felspar is a bright red. The two last specimens are very typical of the granites of the Sinai Peninsula.

Serbal is especially remarkable for the number of diorite dykes which traverse the softer granite, and project like so many teeth, according to Dr. Fraas, from the ridge forming the summit of the mountain. The serrated aspect which one sees in pictures may be due to this cause.

We obtain a considerable amount of information relative to the granites of this region from Professor Milne, who accompanied the late Dr. Beke in search of the true Sinai. They avoided Jebel Musa, and the whole region of the traditional Sinai, and proceeded to the head of the Gulf of Akabah, where Dr. Beke fully expected to find the volcano from which, according to him, the law was delivered. This supposed volcano is situated a few miles to the north-east of Fort Akabah, and turned out to be a granite mountain, of which Professor Milne gives a good description. The rock was found to be very prone to disintegration, but the dykes which traverse it decay still more rapidly.* From Professor Milne also, we have testimony to the predominance of the felspathic element in the granites and the dykes by which they are traversed. Of seventy two specimens examined, only two approached syenite. It is probable that these observations apply mainly to rocks collected near the gulf of Akabah.

---

* Desert of the Exodus, vol. I., p. 27.

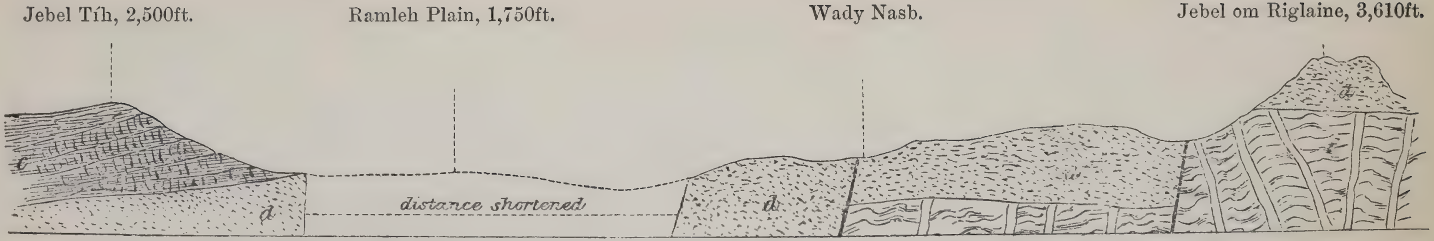
Leaving the crystalline rocks, we now find ourselves face to face with that difficult problem of the *Nubian Sandstone.* The relations of the Nubian Sandstone to the crystalline rocks are well shown in Mr. Bauerman's (Fig. 3) section. This may be regarded as the first stratigraphical aspect of the Nubian Sandstone. As we follow its long exposure on the east side of the Arabah, no base is seen,—this is the second stratigraphical aspect. Then it disappears; and its representative in the Lebanon rests upon the *Glandarius* limestone, and this probably upon the Jurassic rocks of Hermon. I have endeavoured to show this by inserting the wedge-shaped mass, *e*, into the stratigraphical column.

With the help of Mr. Bauerman, let us examine the Nubian Sandstone of the Wady Nasb, where its base is distinctly seen, so that we know that there is nothing but crystalline rocks underlying it. I need not detail the lithological characters, but the chief point of interest lies in the fact that a thin bed of limestone here occurs in it, which contains undoubted Carboniferous fossils. There was much discussion about this at first, but Mr. Holland subsequently sent better specimens, one of which, *Orthis Michelini*, was in very good

---

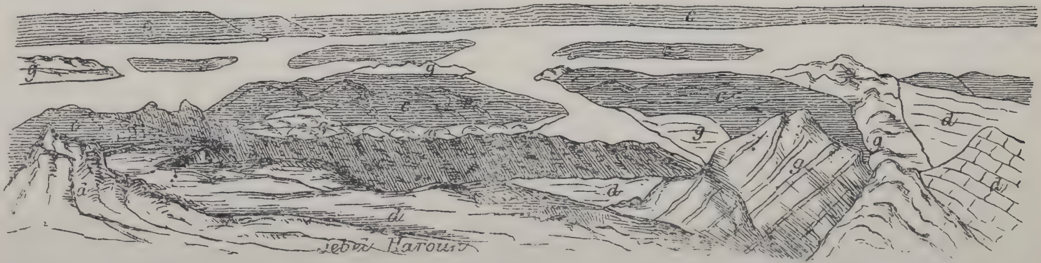
* The episode of Jebel Baghir, or Jebel-el-Nur (the mountain of light), the "true Mount Sinai," first a volcano, then a lightning-haunted peak, is very amusing.

FIG. 3.



c. Cretaceous beds of the Tíh escarpment. *d.* Nubian Sandstone. *f.* Metamorphic schists, porphyries, &c.

FIG. 4.—VIEW OF THE ARABAH FROM MOUNT HOR.



c. Cretaceous. *d.* Nubian Sandstone. *g.* Ancient porphyry of Mount Hor. *x.* Pudding stone.

condition, and Mr. Davidson had no difficulty in determining it. There are other indications that portions of the Nubian Sandstone of the Sinai Peninsula are of the Carboniferous age. There is for instance, in the Museum of the Geological Society, a cast of vegetable impression, marked *Lepidodendron Mosaicum.* Formerly a certain amount of suspicion attached to this fossil, and doubts were thrown upon its being an authentic specimen from the Sinai Desert. It was, I believe, brought to the late Sir Roderick Murchison, and probably received its name from the late Mr. Salter. Since the discoveries of undoubted carboniferous Brachiopoda there seems no reason to doubt the so-called *L. Mosaicum* is a genuine Sinai fossil.

At the base of the Tih escarpment is a fossiliferous deposit containing Cenomanian urchins, &c. There is a strong tendency on the part of both M. Lartet and Dr. Fraas to regard the whole or nearly the whole of the Nubian Sandstone as of Cenomanian age. Dr. Fraas, in his last publication is very decided on this point, and if his statements are to be relied upon, the Carboniferous exposure in the Wady Nasb must present a very exceptional phase.

Let me say a word about the turquoise mines. These occur at Serabit-el-Khadim and other places, in the Wady Nasb district, where they have been worked at intervals of time for ages. This was a great mining country for the ancient Egyptians. The turquoise occurs for the most part in ochreous balls that are situated in certain horizons of the Nubian Sandstone. The best stones are in the solid sandstone, a short distance from the joints. Here again, Mr. Bauerman is at variance with Dr. Fraas, who says, that the turquoise occur in gneiss. The mineral wealth of the sandstone region is very considerable, both iron and copper occuring in abundance. The Arabs were very recently working for turquoise, and have destroyed many inscriptions in these sandstones. Burton, a few years ago, made an expedition into the land of Midian, where the sandstone prevails, and brought away great quantities of minerals.

The last thing to consider is the effect which the Nubian Sandstone has on the scenery of the districts where it prevails. Professor Palmer gives us some capital descriptions.*

---

* Vol. cit., p. 17.

The *red* of Edom is notorious, but Dean Stanley says that it should be regarded as *dull crimson.* His account of Petra in "Sinai and Palestine," is the most vivid description of Nubian Sandstone known to me.

The summit of Mount Hor, where Aaron died, is composed of Nubian Sandstone. Here is a sketch (Fig.4), taken from "La Géologie de Palestine," which may serve to give an idea of the chaos of rocks in that mountainous region. The masses of porphyry form an important feature. These were formerly supposed to be eruptive, as they seem to come through both the sandstones and Cretaceous limestones. Thus it was held by some that the country had been lifted up by these rocks, and that in this way the watershed between the Wady Arabah and the Wady Akabah had been formed. M. Lartet supposed that these are old eruptive masses, belonging to the crystalline series, and that they must have been there before the deposition of the sedimentary beds. This has an important bearing on questions which will be discussed in section VIII.

The cliffs on the east side of the Dead Sea and the deep gorges of the Arnon and Calirrhöe presents splendid sections of the Nubian Sandstone, where they may be seen underlying the Cretaceous limestones of Moab. The sandstone here has fallen 5,000–6,000ft. below the elevated position it occupies on the summit of Mount Hor. The pages of M. Lartet and of Canon Tristram supply us with most graphic accounts of the extraordinary effect of these cliffs. The gorge of the Calirrhöe is especially remarkable, as there the sides of the deep "cânon" are moulded in black basalt, white limestone, and purple sandstone, the effect of contrast being most marked. Canon Tristram says, that the gorge leading up to Kerak is almost Alpine in its grandeur, and that author considers that there is a decided unconformity between the Nubian Sandstone of that district and the overlying Cretaceous limestones.

Throughout the upper part of the Jordan Valley the Nubian Sandstone is lost sight of, but re-appears in the hollow of Syria. Before noticing its character there, we must consider the beds known to occur in Hermon, which in the stratigraphical column are marked under the letter *e*. These are what are known to the Lebanon geologists as the *Glandarius* limestone, which by the testimony of all underlies the so-called Nubian Sandstone of that region. The spines of *Cidaris glandarius* are characteristic of this formation, and have long attracted attention. These were known formerly as "Olives of Sodom," or "Judah stones," though not really found either at Sodom or in Judæa. M. Lartet thought that some portion of the *Glandarius* limestone might be Jurassic, but the Lebanon geologists regard it as of the age of the Upper Greensand: *Syphonia pyriformis*, *Cyphosoma cenomanense*, *Terebratula biplicata* are quoted from it.

The only exposure of undoubted Jurassic rocks occurs on Hermon, where *Rhynchonella lacunosa* has been found on the very summit. There are palæontological indications both of the White and Brown Juras, whilst fossils not uncommon in our Coralline Oolite occur, such as *Ammonites plicatilis* and *Terberatula Maltonensis*, both of which are found in the neighbourhood of Malton. The Brown Jura is represented by Ammonites, such as occur in the Kelloway Rock of Scarborough Castle Hill.

The Lebanon Sandstone is described in considerable detail by Dr. Fraas. The fossils are numerous and leave little doubt as to the Cenomanian age of these beds. Trigonias are very charcteristic, and especially a variety of the group of *Scabra*, one of which is figured in the accompanying plate. There is a considerable amount of contemporaneous igneous rock in these sandstones.

On reviewing the whole question of the Nubian Sandstone, we must admit that the identity of the Lebanon rock with that of the Dead Sea, &c., is not quite so clear as Fraas and Lartet maintain, but in our present state of knowledge we must be content to let the question rest.

5. *The Cretaceous and Nummulitic Limestones.*—The earlier geologists, especially those connected with the Lynch Expedition, believed that there was a considerable development of Jurassic beds, both in the Lebanon and in Palestine proper, and thus many of the fossils are described as Jurassic. There is very little doubt now-a-days that the whole of the calcareous system, with the slight exceptions already made, belongs to the Cretaceous epoch or to yet

newer beds. Hitherto we have met with few traces of fossils, but when we reach an horizon which is represented in N.W. Europe by the zone of *Pecten asper*, *Pygaster lampas*, *Scaphites equalis*, *Ammonites navicularis*, and *Exogyra columba*, there is a great change. This horizon is Cenomanian, and partly corresponds with our Upper Greensand, and it forms the base of the Cretaceous limestones over an immense track of country, extending from S.E. Arabia, and probably even further on the east, to Algeria on the west; so that Palestine forms but a fragment of this extensive area. The deposits of this old sea went on accumulating long after the period when chalk had ceased to be deposited in our own islands, and plainly continued even where Nummulites had become numerous, so that there is no physical break in this great calcareous system. An important change took place in middle Tertiary times, the Cretaceo-nummulitic sediments had become rock, and were subjected to a series of earth movements, such as those which formed the chains of Lebanon and Anti-Lebanon, where this group of beds are folded in undulations which have a general N.N.E. strike. At the same time, the Cretaceous limestones of Palestine were uplifted in the great anticlinal fold, of which Fig. 7 is a cross section. But the complications here are slight compared with those of the northern ranges. It was at this period that the main physical features of the country were written upon it, though the agents of denudation have been carving minor features ever since. We may possibly regard the period of the uplift as Miocene. No marine fossils have ever been deposited since in the area coloured blue on the map, but there are immense deposits of flint conglomerate, gravel and superficial rubbish, which have been accumulating for an immense period of time.

The Cretaceous geology of the Lebanon has been the subject of much study, and of several important memoirs. The first is the memoir by Botta, to which I have already alluded, as the earliest *geological* attempt made in the east; the latest work is the second part of *Aus dem Orient* by Dr. Fraas, published four years ago.

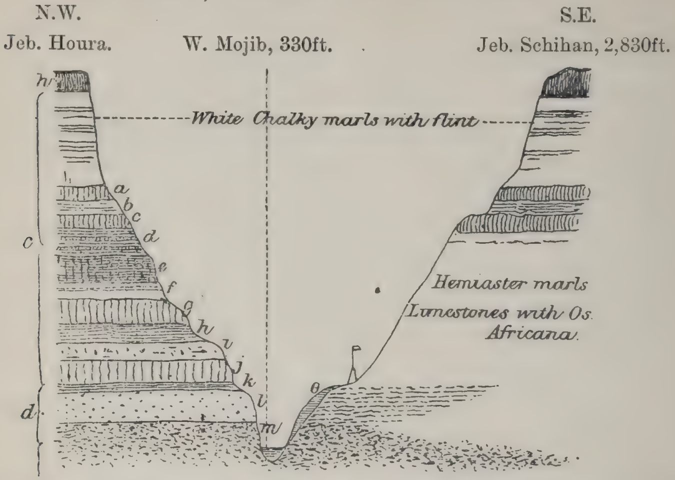
The Lebanon sandstone is credited with the Trigonias already mentioned. Above this comes the Gasteropod zone towards the base of the Cretaceous Limestones. It contains many species of Nerinæa, two of which are figured in the accompanying plate; next succeeds the zone of *Ammonites syriacus.* Dr. Fraas regards this as Turonian, or what we should call lower chalk, the typical fossil clearly having affinities with *A. rhotomagensis*, and other ammonites found towards the base of the chalk at Lewes. The presence of Hippurites in abundance is another characteristic feature. The upper white chalk-with-flints of the Lebanon Dr. Fraas refers to the Senonian or upper chalk, so that he does not regard it in any way as Tertiary. The remains of the Nummulite beds consequently are rarer in the Lebanon even than in Palestine, but evidently increase in importance as we approach Egypt.

It is impossible to quit the subject of the Cretaeous Beds of Lebanon without saying a word about the fish deposits. These are on two horizons, of which that of Hakel is probably the lower. The fishes are all of those species whose bones are perfect, ganoids being absent. The beds therefore are either Cretaceous or Tertiary, almost certainly the former. There is an enormous collection of these Lebanon fishes at the British Museum, and along with these are some wonderfully well preserved remains of cuttle-fish, &c., one of which Dr. Woodward has lately described in the *Geological Magazine.* Other forms are equally well preserved. The Sâhil Alma deposit is thought to be on a higher horizon, near the white chalk-with-flints, and may possibly correspond with an horizon in Palestine, where M. Lartet detected many remains of fish.

We must now return to Palestine. Not the least valuable and original of M. Lartet's work, was that done in the Cretaceous limestones of Moab, a country always difficult and even dangerous to travel in. He gives us a great number of important sections. I have selected the section across the gorge of the Arnon (Wady Mojib), because it shows the whole body of the Cretaceous limestones from bottom to top, everything in fact, between the Nubian Sandstone and the Basalt.

The complete section is rather over 3,000 feet, and when we have deducted some hundreds for the Nubian sandstone at the bottom, and Basalt at the top, there still remains something like 2,500ft. for

FIG. 5.—SECTION ACROSS THE VALLEY OF THE ARNON (W. MOJIB) EAST OF THE DEAD SEA.



a, Limestones with flint weathering red; *b*, marls with *Pholadomya; c*, grey, compact limestones; *d*, alternations of yellow and red chalky marls with tabular limestones containing *Am. Luynesi; e*, yellowish limestone with *Ostrea Mermeti*, var. *minor*, and *O. vesicularis*, var. *judaica; f.* grey marls with *Hemiaster Fourneli, O. olisiponensis, Plicatula, Pholadomya, Venus; g*, marly limestones with bivalves and gasteropods; *i*, yellow limestones with *Pterodontes* and other gasteropods; *j*, limestones with *Ostrea flabellata, O. africana*, var., *Holectypus Larteti, Heterodiadema lybicum, Pterodonta elongata; k*, green saline marl; *l*, white sandstone; *m*, red sandstone.

the Cretaceous limestones. Three-fourths of this, comprising the beds, form *a* to *j* inclusive, represent the middle and lower chalks of Palestine, not necessarily corresponding with the middle and lower chalk of England, but about that horizon. There are beds of hard and soft alternations, containing a recognized and tolerably abundant fauna.

In western Palestine these middle and lower beds are for the most part seen, as here, in the gorges, though sometimes perhaps brought to the surface of the plateau by synclinal folds. These are the beds which it has so often been the fashion to speak of as Neocomian and Jurassic, but whose very lowest horizon contains a fauna which M. Lartet regards as Cenomanian. The gorge of the Wady Mojib also shows a fine section of the upper white chalk-with-flints, from which, at another point near Kerak, a remarkable series of fossils was obtained.

In this one section then we have an epitome of the entire series of the Cretaceous limestones of Judæa and of Moab. These are the beds, and especially the upper chalky ones with flint, whose acquaintance the traveller in the Holy Land is most apt to make. Denudation, going on probably ever since the Miocene period, has carved them out in a variety of ways, and the soft upper beds have received much ill treatment. Sometimes everything has been washed away except the flints, which are left in long rows, or as circlets round banks and knolls of the harder rocks. Sometimes the material from these soft upper beds, fills cracks and crevices in the lower and harder ones. Generally one may say that they make a dry soil, and have a tendency to produce a wilderness, such as that of Judah. This kind of thing is probably repeated in the more terrible desert of the Tih, where perhaps there are considerable developments of Nummulitic limestone in addition. All these upper limestones are impregnated with saline matter, and the water from them is both bitter and unclean.

I ought to say a few words about the palæontology of the Cretaceous beds of Palestine. There are two or three noted localities for fossils. One is reported to be near Jerusalem. At any rate numerous Ammonites are found on a certain horizon there, such as French geologists would call Cenomanian.

They belong to a type not unfamiliar to collectors from the lower chalk or chalkmarl, such as *Am. Mantelli*, *Am. rhotomagensis*, *Am. varians*, and along with these are others not known in England, though for the most part related to the same group. The Nerinæan limestone of Jerusalem is celebrated; it will take a good polish, I believe, and I have heard say that the temple of Solomon was in part constructed of this stone. Its excavation has left great galleries in the rocks beneath. The abundance of Nerinæa is noteworthy. At least twelve species are quoted by Lartet, not of course all from the Jerusalem rock; and it is this abundance of Nerinæa which may have induced the older geologists to regard these limestones as Jurassic, since in our country no Nerinæa is known in beds of later date than the Corallian,* but the presence of the Ammonites named, of Baculites, and especially of Hippurites, leaves no doubt as to the age of these beds.

Amongst the conchifera there are several specimens of Pholadomya. A small but very handsome species is one from the upper chalk of Judæa, figured in the plate. There can be no doubt that it has a tertiary aspect, and reminds one in its deeply chiselled ornaments, of a species figured by Sowerby from the Eocene, I think, of the Isle of Wight. This is probably from Marsaba or Nebi Musa, where there is a well-marked fossiliferous horizon. The most numerous of all the Cretaceous fossils are oysters; these undergo division into several species. The exogyroid forms are related to *Exogyra columba.* The one figured in the accompanying plate is pretty common, and has been identified by Lartet as the oyster of Lisbon *(Ost Olisiponensis)*, described by Sharpe from the Cretaceous beds of Portugal. Sea urchins, especially Hemiasters, are also plentiful.

It remains for me to say a few words about the bituminous deposits of Nebi Musa, which underlie the fossiliferous horizon already mentioned. There is an abundance of bituminous matter in many parts of the Cretaceous series of Palestine, the Lebanon, &c., but this particular place is well-known and often visited, and the black bituminous limestone which it yields is worked up into rosaries and other ornaments by the folks at Bethlehem and Jerusalem. It is known by the name of Dead Sea stone, as the idea of asphalt has always been associated with that lake. The bed of Nebi Musa, however, is a couple of thousand feet above the level of the Dead Sea, and several miles away from it. The limestone, according to Hitchcocks report, contains 25 p.c. of bitumen, and would be valuable as an article for producing asphalt. It is worthy of remark, that just below the chief deposit of bitumen, is a bed full of fish remains. Now, organic matter is the source of all bitumen, which is nothing more than a partially oxidized hydrocarbon with certain impurities;

---

* Mr. Walter Keeping, curator of the York Museum, has lately described and figured a very peculiar *Nerinæa* from the Lower Greensand of Upware. If this is not a *remanié* fossil, it brings the genus down to a much later horizon in our English beds than previously recognized.

it seems to me not unlikely that the putrifactive decomposition of the animal matter of the fish bed, has yielded the principal part of the bitumen. I may here add, by way of parenthesis, that all fossiliferous limestones are more or less bituminous. When a hot sun falls upon certain portions of the Coralline Oolite of Weymouth, the odour of bitumen is strong, just as in the Wady Mohamet, for example, where, according to Lartet and Tristram, the bitumen actually exudes. The only circumstance which causes me to doubt the animal origin of the Nebi Musa bituminous limestone, is that its odour is described as fragrant, which rather points to a vegetable origin. No doubt most of the Lebanon bitumem is due to destructive distillation of vegetable remains in the Nubian sandstone, and much of the bitumen in former times found floating in the Dead Sea, may arise from bituminized wood in Nubian sandstone on the east side dislodged perhaps, by earthquakes. From this source also, M. Lartet would derive the bitumen of Nebi Musa, volatilized by heat through several thousand feet of beds.

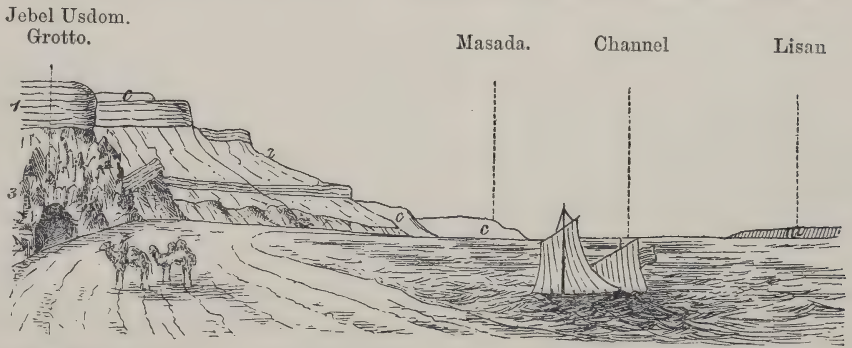
As the subject of sulphur, of which we hear so much in connection with the history of the Dead Sea, is closely related to that of asphalt, reference may be made to a short paper by Dr. Fraas respecting some deposits of sulphur recently observed near Jericho.*

Everybody remembers Lot's wife, and all travellers to the Dead Sea have remarked upon the singular salt deposit in the neighbourhood of which the city of Sodom is supposed to have been located. Fig. 6 is a pictorial section, borrowed from M. Lartet, which may serve to give us some idea of the geological structure of the place. First let me say a few words as to its position. It is a hill, about 5 miles long from N. to S., and a mile broad, which occurs at the S.W. corner of the Dead Sea. This is the shallow south bay of the Dead Sea with the "Sègor" sailing on it; immediately over that vessel is seen the narrow channel between the cliffs of the west coast and the low promontory of the Lisan. These cliffs form part of the great Cretaceous escarpment 2,000 feet high, on which Masada is situated. Perspective causes them to appear so low in the section. On the left of the section is seen the north end of

---

* *Quarterly Statement, Palestine Exploration Fund*, October, 1880, p. 246.

FIG. 6.—JEBEL USDOM AND THE SOUTH END OF THE DEAD SEA.



1, Gypsum; 2, Saline and Gypseous Clay; 3, Rock Salt; *c*, Cretaceous beds, constituting the cliffs on the west side of the Dead Sea, lowered by perspective; *m*, Old Lacustrine Deposits of the Dead Sea basin.

Jebel Usdom, close at hand and only 400 feet high. This is divided geologically into three portions, the lowest (Fig. 6. [3]) is the rock salt, the thickness of which is variously estimated from 80 to 200 feet. It weathers into numerous pinnacles, some much larger than others, and these pinnacles are Lot's wives. By all accounts it must be rather like a crevassed glacier. Upon this come beds of saline and gypseous clay (Fig. 6 [2]), and in this series are regular beds of gypsum ([1]). The whole is supposed to be surmounted by chalk-with-flint, like any other of the higher Cretaceous beds in the district.

Such is the isolated ridge of Jebel Usdom, and many are the speculations as to its origin. Some have regarded it as an old deposit of the Dead Sea, or rather of its predecessors at a higher level like the deposits of the Lisan, but its structure is very different to these extremely thin-bedded deposits. I will merely say that M. Lartet concludes it to be part of the Cretaceous series, where the saline and gypsiferous element is in excess, and he points out certain horizons, especially in the upper chalky beds, where there is a considerable development of salt and gypsum, though nothing like what occurs here. Lartet says that the position of the hill from a stratigraphical point of view is also favourable to the notion, whilst we have already seen that the limestone series south of Jerusalem to the borders of the Sinai sandstone is throughout so saline that decently potable water is very scarce. Somehow the salt of the old Cretaceo-nummulitic sea has never been fairly washed out of it. We must conclude therefore, for the present, that Jebel Usdom is merely an exceptionally saline development of the Cretaceous rocks which form the principal part of the rim round the basin of the Dead Sea.

Canon Tristram, I may observe, who formerly advocated the notion of these being old Dead Sea deposits brought up by a swelling of the ground, has lately abandoned this idea, and now places Jebel Usdom at the top of the Nubian Sandstone, which he is disposed to regard as "New Red." This seems to me a most gratuitous conjecture, although there may be evidence in the background, which that author does not adduce. This concludes the section relative to the Cretaceous and Nummulitic limestones.

6. *Beds of marine origin newer than the Nummulitic limestones.*—Beds with Miocene fossils I have already stated as occurring in the Chalouf cutting of the Suez canal, but whether the whole of the district marked *b* in the map, is to be regarded as Miocene is extremely doubtful. Yet the hollow or depression of the Isthmus of Suez, is, in part, filled in by Miocene beds, and it is probable that since Miocene times, there has been no communication between the Red Sea and the Mediterranean, notwithstanding the very slight water shed. It is said that not a single species is common to the Mediterranean and the Red Sea, whose fauna belongs to the Indian Ocean. The Red Sea fauna extends up to the basin in which the Bitter Lakes are situated; and the Mediterranean fauna is traced southward for some distance, but they never meet. A portion of the intervening ground between Lake Timsah and Serapeum is occupied by freshwater beds, which show that a branch of the Nile, most likely in Quaternary times, flowed through the hollow now occupied by the sweet water canal, past Tel-el-Kebir and Ismailia, where it most probably turned round into the Red Sea. The Etherias of the Nile, now confined to the cataract districts and above, are found in abundance in these deposits near Serapeum. Etheria, I may mention, is a peculiar genus of the family Unionidæ, very characteristic of some of the great African rivers.

Most of the coast deposits in the great bight which lies between Mount Carmel and the delta of the Nile, are regarded by Lartet as Quaternary and recent.

7. *The Volcanic Rocks.*—Under this head I would only include the Tertiary eruptions, interpreting the word Tertiary in its widest sense, as coming down to the present time. Mr. Bauerman concluded that the volcanic rocks of that portion of the Sinai peninsula visited by him were of two periods, of which the second was contemporary with the flint conglomerate.

The twenty-eight *harrahs* of Arabia, in alignment with the Red Sea, the Gulf of Akabah, and the Dead Sea hollow, are remarkable instances of the parallelism of volcanic centres to fissures filled with water. I should mention that a *harrah* means a fire district or volcanic region. One of these, not far from Medinah, erupted during the reign of the Caliph Omar, and this is the last sign of activity of which we have historical notice.

As we travel northwards, small basaltic flows are noticed in Moab, and these prepare us for the great lava-covered districts which lie to the east and north east of Galilee, whilst many smaller ones are noted in Galilee itself. The upland plain of Damascus seems at one time to have been enveloped in a semicircle of fire, of which remains are to be seen in the three huge fire districts of the Safâh, the Ledja (including the Hauran), and the Jaulan. Jebel Kuleib (5,600 ft.) is the Hill of Bashan, and the country thence to the Jordan contains some barren scoriaceous districts, and other of extreme fertility, where, the basalt in decomposing, mixes with a peculiar loam. This probably nourished the vegetation on which the bulls of Bashan waxed fat. Enormous quantities of magnetic iron ore occur in the hill of Bashan, in fact, no part of the country calls for exploration more than this does.

Many of the basaltic blocks are covered with inscriptions and figures of beasts, &c. Basalt, in fact, seems to have been much in favour as a medium for inscriptions. Take the case of the Moabite stone for instance. Canon Tristram says that it was much in favour with the old Cyclopean builders. Most of the specimens from Moab and Galilee brought for analysis are olivine dolerites, extremely rich in iron, and rather poor in silica.

It might be asked, what is the age of these masses of Basalt? When did the eruptions begin, and when were they brought to a close? As a partial answer to the first question, M. Lartet observes that no basaltic fragments have been found in the older deposits of the Dead Sea basin, and, as these include pebbles towards their margin, it would seem as if the basalt had not reached the surface when the oldest Dead Sea deposits were made. On the other hand, there is no tradition which can plainly be identified with volcanic activity, in those regions where volcanic matter is now found. It is plain that the fate of the cities of the plain was in no way connected with volcanic eruptions, as this is just that portion of Palestine which is most free from anything of the sort. The age of the volcanic eruptions awaits further investigation.

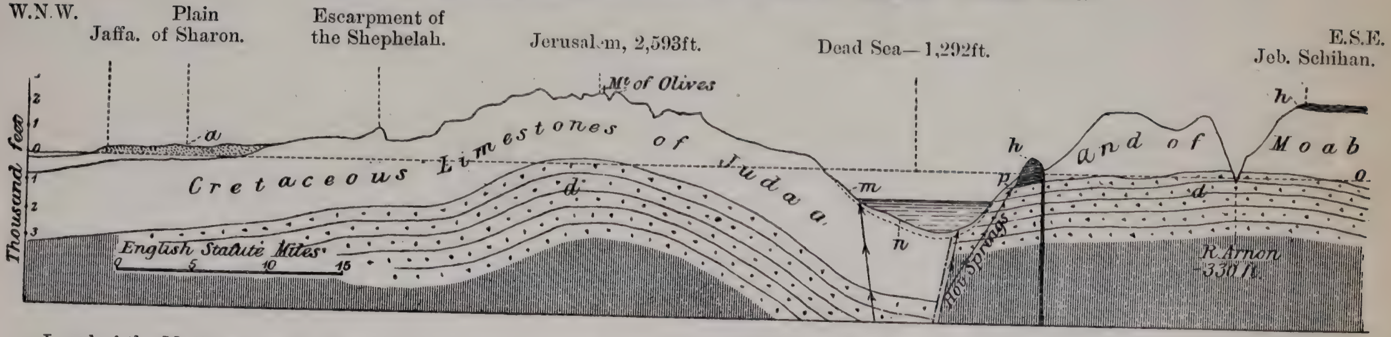
8. *The Jordan Valley and Dead Sea Basin.*—This is the most important of all the sections, and I have been obliged to hurry over some of the others in order to arrive at it. The others being more or less necessary to a correct understanding of this one. By Dead Sea Basin I mean the whole of the longitudinal fissure from the slopes of Hermon to the water-shed near Akabah. The drainage of this finds its way into the Dead Sea, on the north by the Jordan valley, on the south by the Wady Arabah. From the surface of the Dead Sea it is dissipated by evaporation, whereby the level is maintained, and maintained so effectually, that a depth of nearly thirteen hundred feet intervenes between its surface and the level of the Mediterranean, so that the very clouds in this valley are often hundreds of feet below the level of the sea.

Broadly speaking, there can be no doubt of the general connection between the Dead Sea fissure, the Gulf of Akabah, and the Red Sea, right away to the Straits of Babel-Mandeb, and the line of depression is carried north in the hollow of Syria, between Lebanon and Anti-Lebanon, though there above the level of the sea. Such a singular place has been fruitful in theories, and the destruction of the cities of the plain for instance, has led travellers to endeavour to account for the facts of biblical history, by statements too often entirely devoid of truth. The craters of De Saulcy, &c., have no existence. And it so happens that the volcanic eruptions are quite in another part of the country, as we have already seen.

There are two theories which claim our attention as not being obviously inconsistent at first sight with physical facts. One is, that previous to the disaster of the Pentapolis, the river Jordan flowed into the Gulf of Akabah; the other is, that the Red Sea came right up over the present water-shed, and filled the great fissure almost to the foot of Hermon. According to the first view, the whole system would be fresh water, according to the second it would be marine.

Before entering on this question generally, we should direct our attention to the geological structure of this fissure basin, in connection with the high grounds of Judæa and Moab. Figure 7 is a diagramatic section of Palestine from the coast to the mountains of Moab. The Cretaceous limestones rising from beneath the waters

FIG. 7.—GENERALIZED GEOLOGICAL SECTION ACROSS PALESTINE.



o, Level of the Mediterranean; *a*, beds of the maritime plains; *m*, old lacustrine deposits of the Dead Sea basin; *n*, deposits now forming beneath the Dead Sea; *p*, tufaceous deposits of hot springs; *h*, basalt.

of the Mediterranean, and the recent deposits in the Vale of Sharon, ascend by a major anticlinal fold to the plateau of the Judæan highlands, whose physical geography we have already studied. The Mount of Olives and the country to the eastward, is occupied by the very highest beds of the Cretaceous series, the soft white chalk-with-flints. On this side of Jerusalem there occurs a preponderance of easterly dips in these limestones, which the various local sections well bear out. The consequence is that the beds come down with an increasing dip, and thus in all probability pass right under the Dead Sea in the manner shown in the section, where they are sharply faulted against the Nubian sandstone, which is seen only on the east side. Here a general westerly dip is said to prevail, at any rate near the Red Sea, in the manner shown, so that if there is no fault, there must be a synclinal curve with arms of very unequal steepness, which would have all the effect of a fault. Whichever of these views we adopt, the chasm must in the main be due to stratigraphical causes, and not to erosion, as in the case of a canon.

I will also note one or two points which this diagram suggests: The deposits marked *a*, are those referred to so briefly in section 6, the raised beaches, blown sands, &c., of the plain of Philistia and the Vale of Sharon; the deposits marked *m*, are old deposits of the previous Dead Sea, to which allusion will presently be made; the deposits marked *n*, are those now forming beneath the Dead Sea itself; the deposits marked *p*, are those produced by hot springs, of which Zara and Calirrhöe are the most remarkable on the east side of the Dead Sea. There is also a hot sulphur spring on the west side near Masada, which no doubt deposits slightly. Tufaceous limestone, sometimes aragonitic, is the principal substance deposited by these hot springs. There are small eruptions of basalt also on the east side of the Dead Sea. The lines which indicate the upcast pipes of the hot springs, are of course somewhat hypothetical, but there can be no doubt whatever that the thermal conditions of the Jordan valley have some connection with this line of fissure, be it actual fault or unequal synclinal.

Having thus far studied what I may term the geological accessories of the Jordan valley, we must now enquire into the nature and probable age of its deposits, including of course those of the Wady Arabah, and see how far their history bears on the question of the sudden sinking of the Dead Sea basin, which has been supposed by some to have been the cause of the ruin of the five cities.

Now M. Lartet maintains that the great fissure has been an independent basin for a long period, indeed, at one time he was disposed to regard its origin as having dated from Miocene times, but in his latest work *La Mer Morte*, he does not seem disposed to carry it so far back in time. But that it has been an independent basin for an immense period, he considers can be shown in many ways. Firstly, as was noticed by Hitchock, from the surveys of Robinson and Smith, all the tributaries of the Arabah flow in so as to form an acute angle with the main valley pointing to the north, a very strong physical proof that the drainage of that region has not been reversed. On the other side of the Dead Sea the lateral wadies of the Jordan system for the most part point to the south; all the evidence indicating that the drainage has been towards the Dead Sea in former times just as it is now.

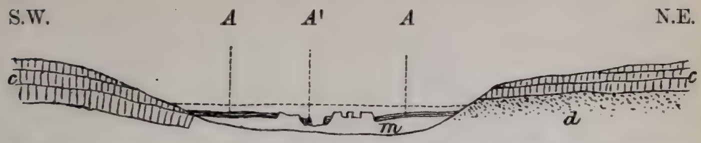
But in spite of these facts, so ably put forward by Hitchcock and Lartet, it must be admitted that the zoological evidence does point to the probability of some connection, doubtless of very high antiquity, with an African continental river system. Canon Tristram, with his usual energy, brought to England numerous specimens of fish from the upper waters of the Jordan system, probably from the lake of Tiberias. Some of these were decidedly of African types. According to Dr. Gunther the following genera occur, viz.: *Chromis*, *Hemichromis*, and *Clarias*. Now *Clarias macracanthus* is a common fish of the upper Nile. But to show the remote nature of the connection, it is a curious circumstance that *Hemichromis* in not represented now-a-days in N.E. Africa, but chiefly in the central African lakes and even in the west coast rivers.

On the whole, Dr. Gunther, who had the examination of Tristram's fishes, demurs to M. Lartet's notion as to the complete independence of this valley system. Nevertheless, an examination of the nature and mode of occurence of the Jordan valley deposits, as shown both by M. Lartet and Captain Conder, prove the very considerable antiquity of the valley as an independent basin, and thus show how impossible is the theory which would date its origin fron the catastrophe of the Pentapolis.

Captain Conder shows four very distinct margins of old lakes, which were predecessors of the present Dead Sea. The present north shore of the Dead Sea is a shingly beach with a ridge of pebbles at the top of a somewhat steep slope. About thirty feet above the top of this is a similar one. This marks the surface of extinct lake No. 1; a hundred feet higher is a third beach, which marks the surface of extinct lake No. 2. Above these beaches, and some 300ft. above the present Dead Sea, are flat shelves of marl, known as the Siddim level; this marks extinct lake No. 3. And there is yet another still higher. All these lakes would obviously fill up a considerable expanse of the valleys of the Jordan and the Arabah, and their deposits would serve to give us some idea of the history of the period. These lacustrine deposits M. Lartet calls the "deposits of the Lisan," from their great development in that peninsula, which wholly consists of them. They are, as a rule, very thin bedded marls with much salt and gypsum, both in beds and throughout the mass, and have considerable resemblance to deposits now going on at the bottom of the Dead Sea, where crystals of salt and selenite are brought up from the bottom, along with blueish marl. From the absence of organic remains, M. Lartet argues that the physical conditions must have been pretty much the same as now, except probably for the greater quantity of water, and this, M. Lartet considers, is due to the much greater humidity of the atmosphere during Quaternary times.

Anyhow, what we have before us in these Jordan valley deposits, is pretty fair evidence, both on the testimony of Conder and Lartet, that neither the waters of the Red Sea, nor of a fresh water system, have prevailed over that area where these saline and gypsiferous marls have been thrown down, and consequently the existence of these old saline lakes at much higher levels than now is proof of the considerable antiquity of the present depression. Indeed, as Captain Conder remarks, no less than four Dead Seas had dried up before the days of Abraham.

FIG. 8.—SECTION ACROSS THE JORDAN VALLEY.



A, Alluvium and other superficial deposits; *A'*, silt of the river Jordan; *m*, old lacustrine deposits.

Figure 8 serves to show the relation of the old lacustrine deposits, which are remarkable for their sterility, to more recent fluviatile and torrential deposits, usually of a much coarser nature, brought down and again cut into by the Jordan and its tributary wadies. This secondary valley in which the Jordan runs is known as the Zor, whilst the larger or primary valley is known as the Ghor. These fluviatile deposits are often just as fertile as the old saline lacustrine deposits are sterile.

There are many other subjects of interest connected with the Jordan valley, such as the evidence of climatal changes, &c., but we have no time for these. Before concluding I must just allude to the hot saline springs in the Jordan valley. Of these I will only mention three, although Dr. Salah Merrill has pointed out several others. It is clear from the abundance of these springs all along this great line of fault, that the forces of vulcanicity are not yet wholly quiescent, although lava no longer flows from the neighbouring craters of Galilee and Bashan. Indeed, so late as 1837, the inhabitants had a reminder of the fact, in the earthquake which destroyed the city of Tiberias and killed thousands of people.

That there is no necessary connection between Sulphur waters and volcanicity the evidence of Harrogate will show, but when waters are thermal over a long line of country, we naturally regard hot water as proof of heat somewhere.

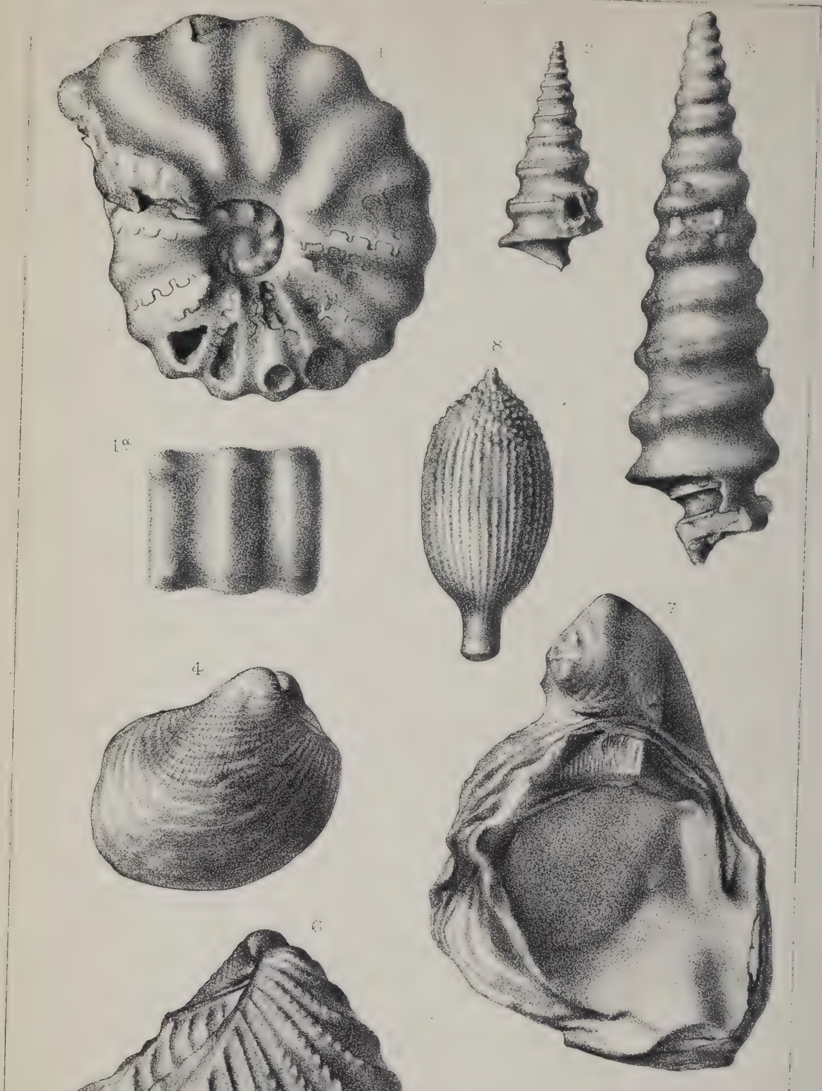
There is a remarkable hot spring at Gadara, near the junction of the Jabbok with the Jordan. I mention this particularly, because, according to Dr. Merrill, this place has natural advantages, which will cause it to become the Montpelier of Syria some day. I think he mentions five sulphur sources. There are magnificent views from this place, which was evidently a favourite one in the days of the

Roman empire, from the numerous remains of villas in the environs. It only requires that the detestable Bedoueen should be driven away, for the place to become one of the most charming in the east. Allusion has already been made to the hot springs of Calirrhöe, and to the marvellous scenery of the gorge in which they occur. These are hotter than the Gadara waters, being about 140° F. This also is about the temperature of the hot springs of Emmaus, on the west side of the Lake of Tiberias, which have been made the subject of analysis. There is considerable general analogy between these waters, and those of Harrogate. The water of Emmaus is a highly saline sulphur water, containing bromide of magnesium in very appreciable traces.

We cannot quit this part of the subject without a word about the waters of the Dead Sea.

Well may the Arabs express astonishment when they see the spring floods of the Jordan swallowed up year after year, without any material increase in the size of the lake. To them the notion of evaporation will hardly present itself,—an evaporation which makes this place the recipient of everything that is soluble throughout the valley.

The waters are so bitter and briny, that the fish of the Jordan are pickled at once, and cast up on its shores. Some persons have started the idea that the waters of the Dead Sea owe their salinity to the vicinity of Jebel Usdom, but when we compare the composition of the salts of the Dead Sea waters with those of the Salt Mountain, it is at once perceived that such can not be the case. The rock salt of Jebel Usdom is nearly pure Chloride of Sodium, so that nothing but common salt and gypsum could be obtained from this source. Let us now turn to the composition of the waters of the Dead Sea. The amount of saline matters vary much according to position and depth. Samples from considerable depths contain $\frac{1}{4}$ of their total weight as dissolved solid matter ; the salts of magnesium exceed those of any other base, and there is a very considerable proportion of bromide. Sodium, calcium and potassium come next in the order named ; all these exist principally as chlorides and sulphates ; carbonates are very scarce. There can be no doubt



G.M. Woodward lith
West Newman & Co. imp

Cretaceous fossils, from the Lebanon & Palestine.

that the numerous hot springs in the Jordan valley have supplied a large quantity of the saline matter; and we know that the one at Emmaus contains bromine. During the long ages when the four extinct lakes were in existence, their waters were relieved by constant deposits of common salt and gypsum, but so very soluble are the haloid salts of magnesium, that these have not even yet been deposited in any appreciable amount, and, although the present lake yet continues to deposit cubes of salt and lenticular crystals of selenite in the marly mud which is forming at the bottom, it would seem that magnesian salts still remain for the most part undeposited. Thus the present Dead Sea contains the magnesian chlorides and bromides, not only of its modern affluents, but those also of its four progenitors.

The deductions which the chemical geologist is enabled to draw from these facts, are not the least valuable among the many marvels of the great Syrian fissure.

EXPLANATION OF PLATE VII

Fig. 1.—*Ammonites syriacus*, Von Buch. Lebanon.
Fig. 1*a*.—Portion of back of same specimen.
Fig. 2.—*Nerinæa* cf. *gemmifera*, Coq. Abeih, in the Lebanon.
Fig. 3.—*Nerinæa* cf.*Coquandiana*, d'Orb. Abeih, in the Lebanon.
Fig. 4.—*Pholadomya Vignesi*, Lartet. Judæa.
Fig. 5.—*Procardium*, species. Abeih, in the Lebanon.
Fig. 6.—*Trigonia scabra*, Lamarck. Abeih, in the Lebanon.
Fig. 7.—*Exogyra olisiponensis*, Sharpe. Judæa.
Fig. 8.—*Cidaris glandarius*, Lang. Lebanon or Hermon.

A GLACIAL DEPOSIT NEAR DONCASTER. BY THOMAS HILL EASTERFIELD (PL. VII*a*)

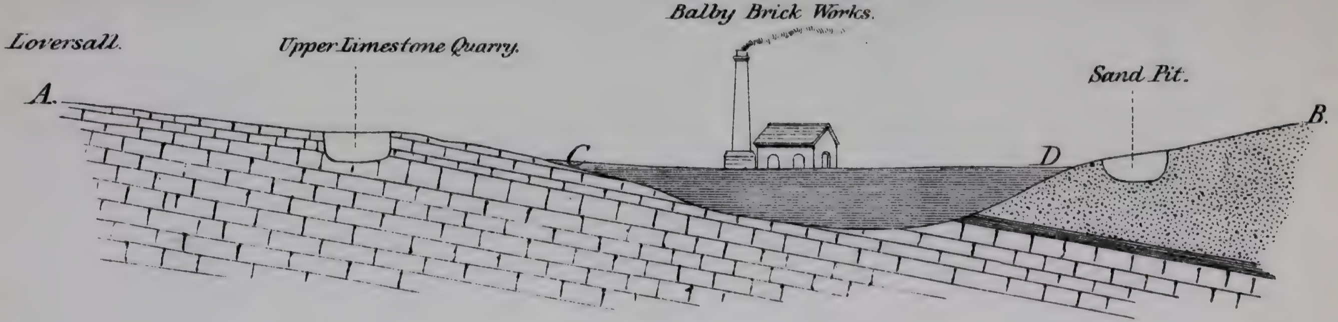
SPEAKING some months ago with Mr. Furnival, of Doncaster, our conversation turned upon glacial deposits, and Mr. Furnival stated that the clay in a clay-pit two miles south-west of Doncaster, and known as Balby Brick Works, appeared to be of the nature of a "Boulder-Clay." I took an early opportunity to visit the pit, and found it to be undoubtedly what is known as "till." It consists of a tough dark-blue clay, packed with boulders up to half-a-ton in weight. The boulders are mainly of local origin, magnesian-limestone, clay-ironstone, and coal-measure shales and sandstones being most abundant; though not unfrequently, carboniferous limestone and upper permian marl with gypsum are found, as are also a few small boulders of hæmatite. One very small block appears to be of the nature of a quartz-felsite. Very many of the boulders are beautifully scratched and polished by the action of the ice.

From a boring made some years ago it appears that this clay is sixty feet in thickness. It covers the outcrop of the New Red Sandstone at its junction with the Magnesian Limestone, there being a limestone quarry near one end of the clay, and a sand-pit close to the other, as in the section on the opposite page.

The section is ideal, only being intended to convey a rough notion as to the general lie and position of the beds.

The clay consists of two parts, an upper and a lower, and the surface of the lower appears to have been smoothed by the ice before the upper was deposited. This division in the clay seems to indicate a cessation in the glacial action, but there is no distinctive difference between the boulders of the upper and those of the lower clay, though there is rather more magnesian limestone in the lower than in the upper.

Section at Balby Brick Works, near Doncaster.



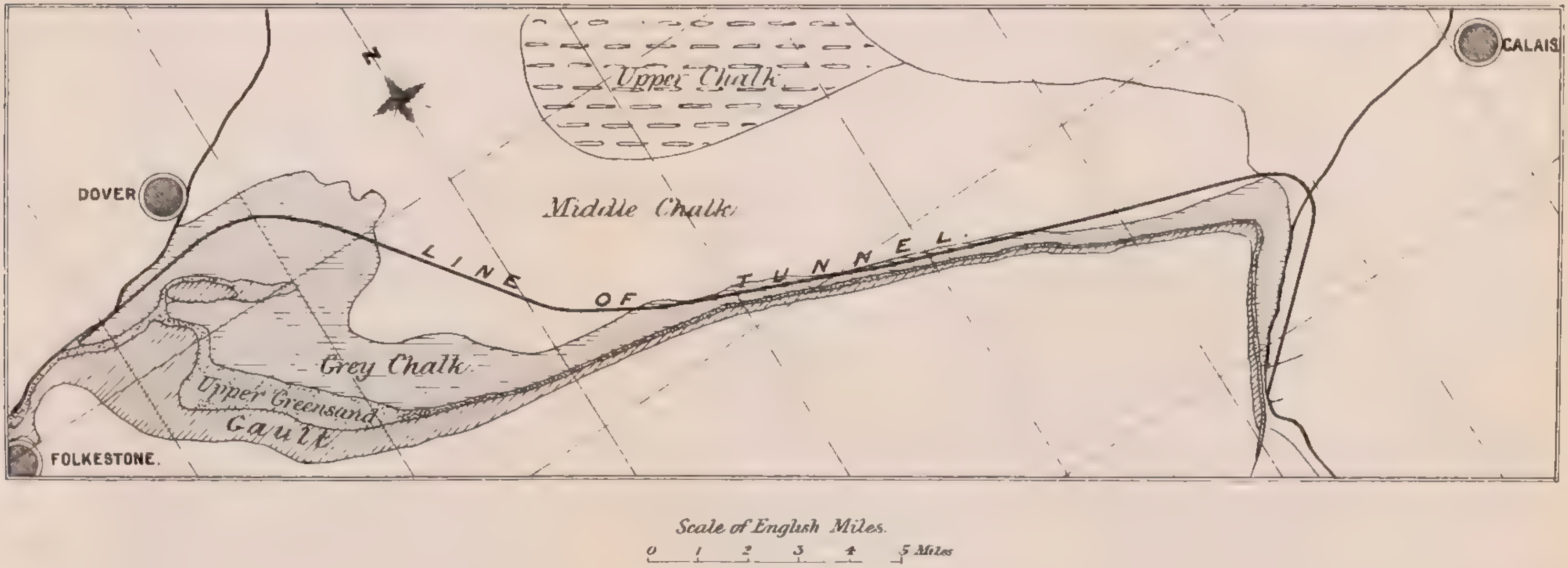
From C. to D. is about 300 yards; in the direction at right angles to this the distance has not been determined, it is however at least a quarter of a mile.

A Megson & Sons, Leeds

Proc. York Geol and Polyt Soc N.S. Vol VIII Pl VIII

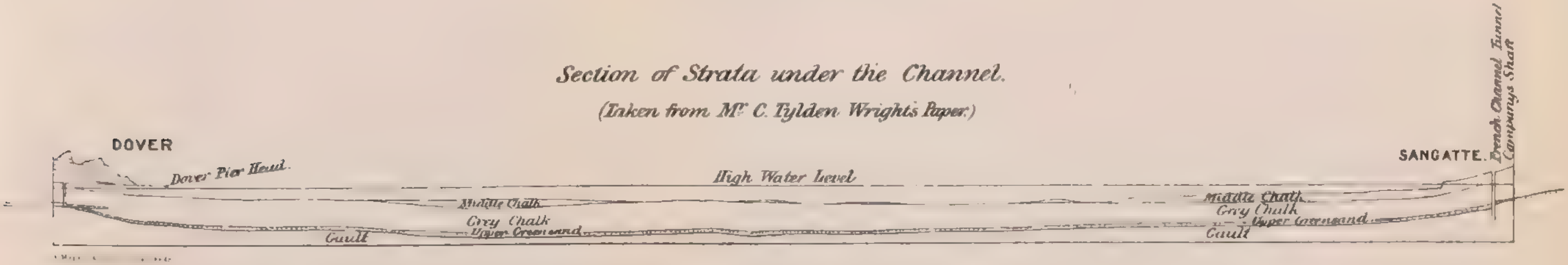
Geological Plan of the Channel between Dover and Calais.

(Taken from Mr C Tylden Wright's Paper.)



Section of Strata under the Channel.

(Taken from Mr C. Tylden Wright's Paper.)



Horizontal Scale 3/8 in to 1 mile
Vertical " 1600 feet to 1 inch

NOTES ON A VISIT TO THE CHANNEL TUNNEL. BY ARNOLD LUPTON, M. INST. C. E., F.G.S., ETC. (PLS. VIII. AND IX.)

THE writer is indebted to the paper of Mr. C. Tylden Wright, read at the North of England Institution of Mining Engineers; and to other sources for much of the information contained in this paper. From these, as well as from his own notes, he has obtained various details, and has prepared the diagrams to illustrate his remarks.

Last November (1882), the writer was invited to accompany a party of Mining Engineers, to visit the works of the Channel Tunnel near Dover. A shaft 163ft. deep is sunk between the Railway and the sea-shore, and from the bottom of this, a small tunnel 7ft. in diameter is driven a distance of 2,000 yards under the sea, in the grey chalk, may be described either as a *soft stone* or as a *hard clay*. The plan and section will explain their relative position.

It is proposed to drive the tunnel with an inclination down-hill of 1 in 80 from the shore at each end, for a distance of 2 miles, and then to drive it with a rising gradient of 1 in 2,000, to the centre of the channel, so that the water met with under the sea, may run to within two miles of the shore, from which point it may be pumped in pipes, or conveyed by a level heading to the shafts, and there pumped to the surface.

The heading is driven by the machine of Messrs. Beaumont & English, which cuts away the whole face of the headings, and delivers the fragments at the back of the machine; it will advance ⅝ inch a minute (as witnessed by the writer), this is equal to 37½in. an hour, viz.: 1 yard an hour or 24 yards a day, which equals 4¼ miles a year without working on Sundays. This, with an equal rate of progression on the French side, amounts to 8½ miles a year, and the distance of 22 miles (21 yet to drive) will be accomplished in 2½ years. It is quite reasonable to suppose that this may be done, because the machine has been driven at a greater speed than given above, upwards of 40 yards having been driven in one day. It is intended to drive the tunnel at such a gradient that there shall not be less than 150ft. of strata between it and the deepest part of the sea. The stratum of grey chalk is 226ft. thick, and extends all the way from the French to the English coast; it is a water-tight stratum; at the English end only a few drops of water are to be seen in the tunnel, at the French end there is a good deal of water owing to some faults.

It is not likely that much water will be met with in driving the tunnel, as owing to the soft clayey nature of the grey chalk, it is hardly possible for it to contain any fissures, because the weight of ground and water above, would tend to consolidate the ground. But if water should be met with, even in large volumes, it can be tubbed out with cast iron cylinders, by a process well-known to the sinkers of coal shafts. Each feeder of water can be tubbed out as it is reached, so that the total volume of water to be dealt with at once, need never exceed a quantity that can be easily pumped up.

After the 7ft. heading has been driven, it will be enlarged to a tunnel 14ft. wide inside the lining; the lining is to be made of cement concrete, the grey chalk excavated from the tunnel being used for this purpose. It is proposed to make two separate tunnels, one for each line of railway. This will be easier to make than one large tunnel, because the chalk is not strong enough to stand in a wide excavation; and also, because if an accident should happen to one line, the other will not be blocked. And it will diminish the first cost of the tunnel, because one line can be completed and worked before the second line is made, and traffic developed.

The cost of the tunnel need not apparently be very great, because there is no money to be paid for the land, and it would be impossible to find any ground more suitable for a tunnel than the grey chalk.

The tunnel cannot be worked by steam engines, the products of combustion would be too dangerous and offensive; but it may be worked either by compressed air or electrical engines. There is no reason why compressed air locomotives should not be used; they are used now to a considerable extent in coal mines and elsewhere. The loss of power in using compressed air is very large, from 60 to 80 per cent., but this is compensated for to a great extent by the greater economy of the stationary air compressor as compared with a locomotive; the boiler of the latter is expensive to repair, and it requires the best fuel; a stationary air compressing engine need not use more than 2lbs. of cheap fuel per horse power per hour, and this will not mean more than 10lbs. of fuel per indicated horse power of the locomotive. Taking all the circumstances into consideration it will be difficult to find any much more economical power than compressed air; and it has this advantage, that the air given off by the locomotive will be sufficient for the ventilation of the tunnel.

The locomotive proposed it is thought will take a train weighing 150 tons, gross, at the rate of 30 miles an hour. Whilst the exhaust air from the engines will very likely suffice for absolute needs, yet it will probably be advisable to have a regular current of air, about 50,000 cubic feet may be sufficient, and this can be obtained by means of a fan and engine, such as are used for ventilating coal mines.

At present Colonel Beaumont has a locomotive made ready for hauling the dirt out of the tunnel, which is now working on the surface. It is a small locomotive using air at a pressure of 1,000lbs. which is heated by a very small coke fire, this facilitates expansion and prevents freezing in the ports, the air is expanded down to atmospheric pressure by compound engines of which the high pressure cylinders are 2 in. in diameter and the larger cylinders 7 in. in diameter.

The tunnel, whilst it is being driven will be ventilated by the exhaust air from the excavating machinery. It is now lighted by the "Swan Electric Lamp," of which there is a series fixed along the side so that the whole length is illuminated.

There is also no doubt that the traffic in the tunnel might be worked by electricity as a motive power. And before the tunnel is completed it is probable that great progress will have been made in the construction of large engines worked through the agencies of magnetism.

It is quite possible to construct both the tunnels under the sea at the rate of £50 a yard each, or a £100 a yard for the two, which amounts to £176,000 a mile, and 25 miles at this rate will amount to £4,400,000 or with approaches, apparatus for air compressing, rolling stock, &c., &c., say £5,000,000 in all. The interest in this at 4 per cent. will be £200,000 a year. It is difficult to see how the tunnel can fail to be profitable. Suppose for a moment England and France to be connected by a narrow isthmus, can it be supposed that a railway to connect the two countries would not pay, and if so the tunnel should pay well. The cost of the London and North Western Railway is about £60,000 a mile, which at present prices of stocks is worth about £105,000 a mile. Taking the cost of the tunnel and approaches at £5,000,000 and the length of the tunnel and approaches included at 31 miles (the approaches costing per mile much less than the tunnel), it equals about £161,000 a mile; when the great length of comparatively unprofitable line possessed by the London and North Western Railway Co. is considered, and the fact that all the railway systems of two great countries will converge at the tunnel, there can be no doubt that the expenditure will be profitable from a commercial point of view.

With well-built and well-lighted carriages, the journey will be at least as pleasant and safe as travelling at night is on an ordinary railway, and there can be no doubt at all that the passenger traffic between England and the Continent will be enormously increased; the dread of sea sickness is a real and widely operative cause for people stopping at home, both with Englishmen and foreigners.

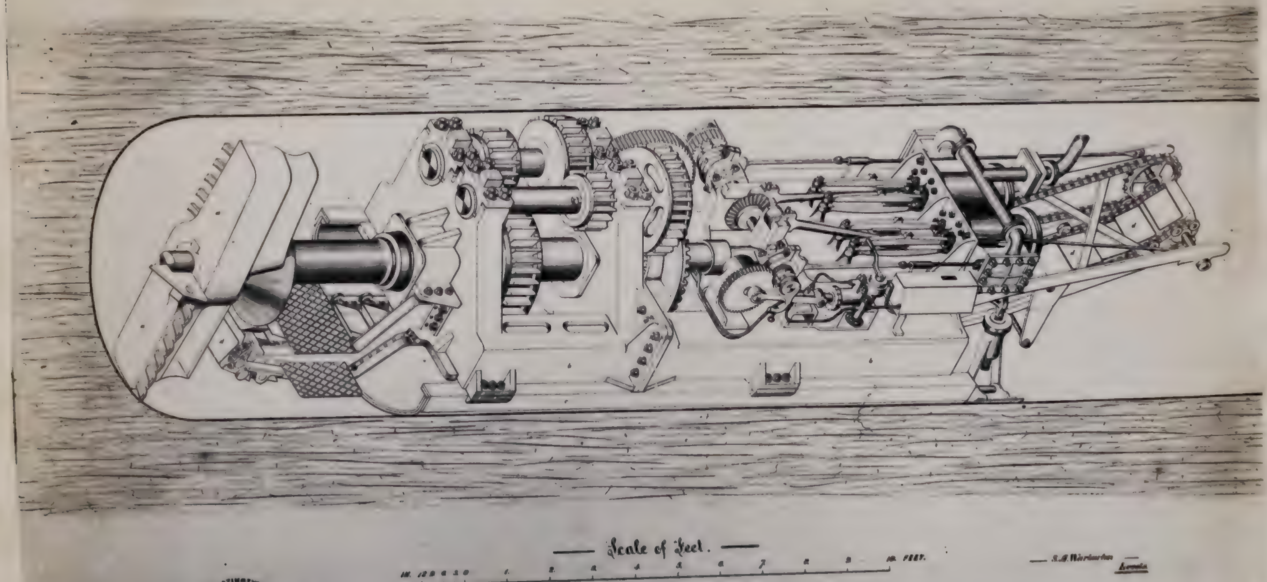
The only real objection to the tunnel is the danger in case of war; the danger is not of soldiers coming through in the first instance, but of a landing from ships of a large army which would seize the tunnel head and then be able to obtain supplies and reinforcements which our fleet would be powerless to stop. It is, however, possible to diminish if not to destroy this danger, by constructing near the entrance to the tunnel a fort of iron or steel, which should be absolutely impregnable and armed with powerful cannon. A garrison of 1,000 men would be sufficient to man a steel fort 100 feet high and 100 feet in diameter, which would have deep cellars in the rocks containing ample stores of all kinds and accomodation for the men.

An army of 50,000 men would vainly strive to take a fort of steel whose entrances would only open to pour forth a withering fire from monster ordnance directed to the tunnel, or opposing batteries, or from rifles, or machine guns, directed by carefully chosen men who would be absolutely protected from the enemy's fire; the fort would also be assisted by the fleet; because unless our fleet had the command of the channel, the enemy would not

To illustrate Mr. Arnold Lupton's paper on "The Channel Tunnel".

SECTION OF THE PRESENT HEADING UNDER THE SEA AT DOVER,

SHOWING THE AIR BORING MACHINE OF COLONELS BEAUMONT AND ENGLISH IN ISOMETRICAL PERSPECTIVE.



S. A. Warburton
Leeds

PLATINOTYPE.
PERMANENT PHOTOGRAPH.

require the tunnel by which to bring up his reinforcements, as they would come by sea.

The cost of such a fort, exclusive of its armament, need not be more than £620,000, or say one million including armament, or in other words, an impregnable land fort could be made and armed for the cost of a first-class ship of war. With the knowledge that such a powerful fort existed, no foreign General would venture to land an army in England, whose only chance of safety depended on the tunnel as a base of operations, and thus whatever danger might arise from the tunnel would be continental, and that without cost beyond this outlay, because the garrison of 1,000 men could be easily provided, out of the standing army already existing.

Many contrivances for flooding the tunnel, or otherwise stopping it, even after an enemy had got possession of it could be provided as additional precautions, and the tunnel once stopped, the enemy having no base of operations, or chance of reinforcements, would have to surrender at discretion, unless our fleet was also destroyed, in which case the tunnel even if open and in the enemys' hands would not add appreciably to our danger.

The writer therefore considers that it is demonstrated that the construction of the tunnel is practicable, that it will be profitable, and no cause of danger to any one.

ON THE SEQUENCE OF THE PERMIAN ROCKS NEAR RIPON. BY REV. J. STANLEY TUTE, B.A. (PL. X.)

THERE is considerable difficulty in determining with certainty the bottom beds of the Permian Rocks, near Ripon. Some beds, indeed, are seen to rest unconformably upon the Plumpton Rocks, as in Studley grounds beneath the 'Surprise,' near the Abbey, and at Knaresbro'. But these seem to me not to be actually the lowest beds of all, though, of course, they are the lowest in those places. Other beds occur as at Nordhouse, in Aldfield, and Well; which cannot be assigned to any position among the rocks which appear in these three places, or in the rocks above them, and must, therefore, have an horizon below. The Carboniferous Rocks had suffered immense denudation before the Permian period. If the Coal Measures ever existed in this neighbourhood (which I doubt), they had all been washed away, and much of the underlying millstone grit. If they did not exist, then the grit must have been exposed during the whole period of the Coal Measures to aerial denudation, and the consequence must have been the formation of considerable river-valleys, into which, as the land was sinking during the Permian period the sea flowed, and the earliest deposits would naturally be made in these ancient valleys. In lithological character also, as well as in the manner in which the fossils are preserved, the beds at Aldfield and Well, differ from the rest of the Permian series. At Well, the fossils seem chiefly to consist of Producta horrida; at Aldfield I have found more than twenty different kinds, most of which occured in a very thin band of clay, which has now been exhausted by the extension of the limestone workings.

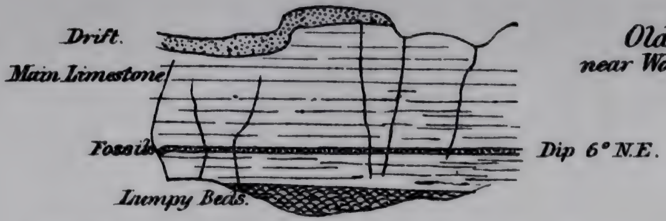
The bed which seems to lie above this conssits of small slabs of yellowish limestone containing Axinus obscurus, very similar to the Garforth limestone, near Leeds.* It occurs in the Studley ground beneath the "Surprise"; and at Hob Green, in Markington. It is difficult to determine the actual thickness of these two beds, but they certainly cannot together be less than 50 or 60 feet.

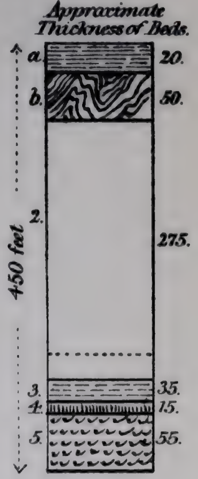
Above them is another bed, well exposed in Markington, of at

---

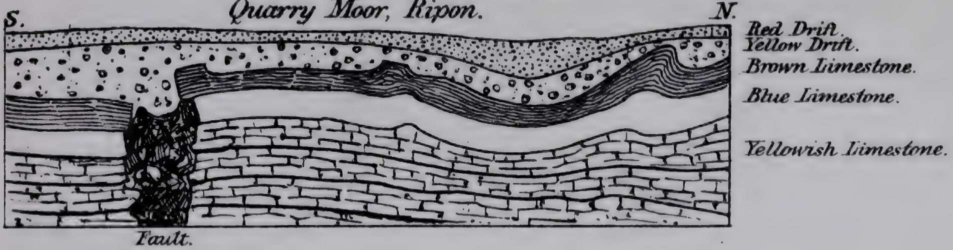
* At Garforth, the Limestone lies upon a bed of sand, which seems to have been derived from the Carboniferous rocks, and is probably a passage bed of Permian age.

Old Quarry near Wormald Green.

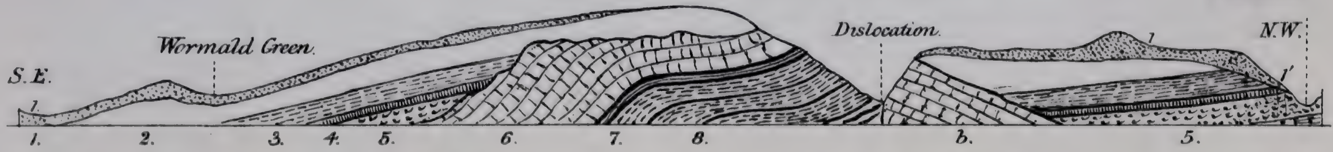




Quarry Moor, Ripon.



The Skell, East of Fountains.



1. Upper Boulder Clay. 1′. Lower Boulder Clay. 2. Main Limestone. 3. Lumpy Beds.
4. Garforth Beds. 5. Nordhouse Limestone. 6. Plumpton Grit. 7. Cayton Gill Beds.
8. Lower Grits. a. Upper Limestone. b. Contorted Beds of Gypsum.

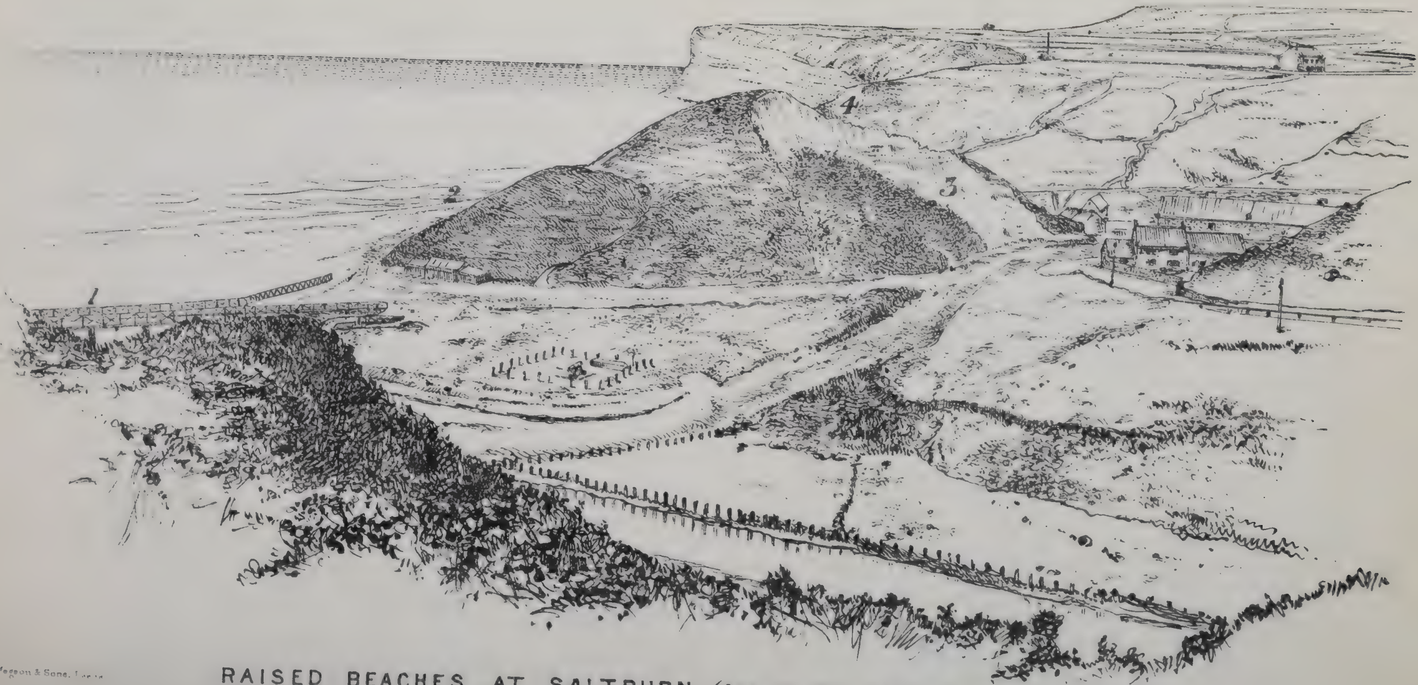
least 50 feet in thickness, of a peculiar character. The surface of each layer is irregularly covered with small lumps or bosses, as if the Permian sea had been subjected to a set of various cross currents, which disturbed the natural process of horizontal stratification. It is a somewhat dark, yellowish, unfossiliferous limestone, full of the sparry cavities so characteristic of the Magnesian limestone. To this bed succeed others of solid limestone, which form the main deposits of the district, and are probably about 275 feet in thickness: they are quarried at Wormald Green, Markenfield, Quarry Moor, and in many other places. In some of its lower beds this limestone is a good building stone, of an agreeable creamy-white colour; but more suitable for interior than exterior work. Fossils are occasionally found, as in two layers in an old quarry near Wormald Green. Old weathered stones also occasionally exhibit the presence of fossils, though they can seldom be separated from the matrix. In the upper beds in a quarry a short distance west of Markenfield Hall, there are many casts of fossils. Here the limestone is of a darker colour, and not so pure.

In the quarry belonging to Markenfield Hall, the limestone presents in its structure a close resemblance to the limestone at Ryhope, in the county of Durham, and in an old wall near the Hall I have found a portion of limestone of the same hard semi-crystallized form as that of Tunstall Hill, but have never discovered the bed from which it was taken. We may, therefore, assign the Markenfield beds to the same horizon as the Ryhope Limestone. Belonging to the main limestone there is a bed which is perfectly oolitic in an old quarry in Whitcliffe Lane. At Nidd Rock an oolitic limestone has disintegrated into a kind of gravel of small rounded grains, but larger than those in Whitcliffe Lane.

The whole of these rocks seem to have been deposited in a shallow sea; for at Wormald Green the clay-partings are strongly ripple-marked, and many layers, when weather-worn, exhibit marks of false-bedding. Above the main limestone I am inclined to place the beds of Gypsum, which occur north of Ripon. They consist of layers of Gypsum and a red sandy clay which have been violently contorted, and they are about 40 feet in thickness. They are overlaid by the horizontal beds of the Upper Magnesian Limestone. As far as I have been able to discover, the whole series has only been slightly dislocated. At Nordhouse, there are two parallel faults running N. and S., throwing down the strata about a yard. At Monkton Mains Quarry there is another small east and west fault, and a third at Quarry Moor. The strata are occasionally bent, as at Quarry Moor and Wormald Green. There is a fault, however, running east and west from Fountains Abbey, and passing a little to the south of the "Surprise," which seems to have thrown down the Magnesian Limestone considerably to the north. At Wormald Green, when the drift is removed, the surface of the limestone exhibits evident marks of denudation,—it is sometimes worn into "pot-holes," sometimes into rounded and smoothed bosses. But I have not seen anywhere traces of glacial striations, except in a few Magnesian limestone boulders picked out of the drift.

SOME INDICATIONS OF A RAISED BEACH AT REDCAR. BY REV. J. S. TUTE, B.A.

AT Warrenby, a new village near Coatham, there is a bed of sandy clay, containing many shells of Rissoa ulva, with broken mussel and cockle shells, &c., and the vertebræ of fishes. Sections were obtained when the foundations were made for the houses, showing a horizontal structure. Here the surface of the land is about 14 feet above high water mark. It would appear that these shell beds were the estuary deposits of the Tees, and that the coast has been raised probably 20 or 25 feet since they were deposited. On the east side of Redcar the Boulder-clay is about 6 feet above the high water mark, and only rises at a very small angle to the east. The upper portion is black, sandy, and peaty, passing insensibly into the browner clay below. This again seems to indicate the former existence of a lower level. These indications of a raised beach are, however, not absolutely conclusive evidence, but I think it is worth while to draw the attention of Geologists to them.



A. Megson & Sons, Leeds

RAISED BEACHES AT SALTBURN. (SEE MR W. Y. VEITCH'S PAPER.)

ON THE RAISED BEACHES ON THE NORTH EAST COAST OF YORKSHIRE. BY W. Y. VEITCH, ESQ., M.D. (PL. XI.)

AT the estuary of the Tees, and on the adjoining coast, there are several indications that alterations in the sea level have taken place, embracing a period ranging from pre-glacial to recent times. They are, perhaps, of sufficient interest to be recorded, and this ought to be done as nearly as possible in the order in which they probably occurred.

Ancient river beds.—The most convenient physiographical records as a starting point, are the ancient river beds. The numerous borings taken in this district, prove that the pre-glacial stream which carried off the water to the sea from this neighbourhood, did so at a level considerably below the present low water mark. Its bed is traceable from the river Tees, near Newport, where it enters the county of Durham, and takes the direction of Saltholme, where it is ascertained by a boring to be 98ft. deep, and filled with sand and gravel; the following is the section:—

	FEET.
Sand	35
Warp (a fine carbonaceous mud)	15
Sand	23
Warp	23
Gravel	2
Into the red sandstone	1
	99

It is next traced to Port Clarence, where boulder clay at a depth of 77ft. was proved, according to the following section:—

	FEET.	INCHES.
Soil	1	6
Clay	4	—
Dark Sand	7	6
Clear Sand	26	—
Red Clay	3	—
Sand and Gravel	8	—
Boulder Clay	27	—
Into the red marl.		

By the following boring it is indicated at the works of Messrs. Bolckow, Vaughan & Co., at Middlesbrough:—

	FEET.
Made ground (Slag, Chalk &c.)	11
Dry Slime or River mud	8
Sand with water	10
Hard Clay (dry)	10
Red Sand with a little water	1
Loamy Sand do	3
Hard Clay	15
Rock, mixed with clay and water	11
Rock, mixed with clay, dry	1
Into Gypsum.	
	70

On the south side of the Tees, at the Tees Tilery, near Eston ironworks, boulder clay was proved over 100ft. deep. The valley persued its course past Kirkleatham to near Marske, where it joins the German Ocean, from under the boulder clay cliffs which guard this part of the coast. Borings near North Skelton, four miles south of Marske, show that the stratification has been washed out to a depth much below the bed of the present stream, and has been replaced by boulder clay, the inference being that this indicated the bed of a stream probably tributary to the one just described, which must have carried its water much further east than the present coast, to join the sea.

Glacial era.—Making these river beds the starting point, next came the glacial disturbance, about which my remarks will be limited to the evidence it furnishes me bearing upon my subject. It almost overwhelmed this district, grinding up the country, leaving striations recording the direction it travelled upon the local rocks, making Eston Nab, Hob Hill, and Roseberry Topping outlyers, bringing *débris* and boulders from the western part of the island, and filling up the submerged river beds. There being no boulders or drift above 800ft. in Cleveland, this, therefore, marks the highest point to which the water attained, although the ice must have passed over the Penine range at an altitude of 1,450ft., to bring over the fragments of Eden valley and lake district rocks, which are scattered so plentifully about.

Perforated stones at Wilton.—Having been informed upon very good authority, that there were to be found on the Wilton Castle escarpment, near Redcar, blocks of perforated rocks having the shells of Pholadomya still retained in their cavities; the blocks being stones from a higher horizon than the rocks on the adjacent coast, all of the same kind of stone as the stratification near to which they were found, led me to believe that they might possibly record a beach somewhere about 150ft. above the present sea level, probably marking a pause in the upheaval which followed the submergence just referred to. I visited this part of the district in search for the Pholas bored blocks, but failed to find them. Subsequently I again searched, being this time accompanied by my friend, Mr. Barrow, of H.M. Geological Survey; disappointment again resulted. Mr. Barrow is, nevertheless, certain of their existence, and undertakes to point them out after referring to his map. It will, therefore, be unnecessary to say anything further upon this part of the subject at present.

Submerged Forest.—The next to be considered is what are generally termed the peat beds of Hartlepool and Redcar. Situate on both sides of the mouth of the river Tees, there are large tracts of peat and wood, suggesting either that they are the remains of an ancient forest, or accumulations of vegetable matter brought down from higher ground. On the north bed of the river the peat at the sea shore overlies the new red sandstone between the Stranton beach and the Longscar rocks. On the south side a similar bed is found over the lower lias between Redcar and the Saltscar rocks. After rough seas they are sometimes bared, and may be noticed to rest immediately upon fine blue clay, here and there stumps are to be seen with roots spreading through the peaty matter into the blue clay below, evidently in the position in which they originally grew. This same fact was observed by Mr. Charles Harrison, while engaged in superintending the construction of the Hartlepool Docks, where the same forest remains were come upon. Logs of wood, branches, twigs, and nuts are embedded in the mass, there being recognisable, oak, beech, and hazel, together with its leaves and nuts

The Tees Conservancy Commissioners in their dredging operations near Middlesbrough and Eston have brought up huge trunks of oak and vast quantities of vegetable matter, in fact, forest remains similar to the components of the sunk forest at Hartlepool and Redcar. Several antlers of the red deer have also been taken from amongst the vegetable remains. One of these trunks of oak is preserved in the Albert Park, Middlesbrough, and when placed there it weighed eleven tons.

Thinking it possible that the deposit might extend inland, that is, to the west at Stranton, I obtained the following section from borings made in search of a water supply:—

Boring at the West Hartlepool Ironworks:—Passed through 50ft. of gravel and clay before penetrating the new red sandstone.

Boring at the Seaton Carew Ironworks, half-a-mile to the south of the last boring:—Passed through 60ft. of gravel only, before reaching the new red sandstone.

Attention will now be drawn to four sections which will throw some light upon the probable time at which this mass of vegetable matter was formed. In clearing away matter to form the central dock, at West Hartlepool, the following notes were taken:—

	FEET.
Gravel	3
Peat with numerous trees *in situ*...	6 to 8
(This bed thickens towards the timber ponds where it becomes 40ft. thick)	
Blue Clay varying from	2 to 6
Boulder Clay bored into*	20

We must now go to the Saltholme boring of Messrs. Bell Bros., where we have

	FEET.
Peat, earth and clay	8
Blue Clay	32
Brown and Red Boulder Clay	56

Passing on to the south of the river Tees to the Middlesbrough Graving Dock, there is

	FEET.
Peat	7
Silt	3
Into Boulder Clay	5

A section near Lackenby, beginning 9ft. below high water mark, gives

	FEET.
Sand and Silt	22
Blue Clay	3
Into Red Clay, no doubt Boulder Clay.	

---

* It is most probable that the thickening of the bed at this point is due to the gradual dissolving and washing out of the permian limestone below it during the growth of the forest, as it is here that the magnesian limestone crops out from under the new red sandstone.

These sections prove conclusively the post-glacial position of the forest remains. The presence of large numbers of the trees in the position in which they grew, and the absence of shells and other estuarine *débris* in the peat satisfies me that the deposits are not estuarine accumulations drifted from a higher level, but are the remains of a forest still located in its original locality. If these observations are accurate, they indicate a further upheaval followed by a submergence.

Raised beach at Saltburn.—A record of this kind of movement exists at Saltburn, where clear evidence of a raised beach, resting upon mid-glacial drift is noticeable; it is 35 feet above high-water mark, and consists of a band of alluvial sand containing shells and fragments of shells, such as Purpura, Litorina litoreæ, Trochus cinerarius, Natica globosa, Lachesis minima, and Cypræa Europæa; the two last being less common than the others.

The Saltburn Improvement Company have laid this beach bare along the precipitous drift cliff, extending 70 or 80 yards from the bridge (1, see Photo.) up Saltburn Beck, where it abruptly comes to an end. In baring and altering this cliff evidences of ancient kitchen middens, which once existed, have been completely effaced.

Last year Mr. Teall, Mr. Howell, and myself, jointly examined the beach, and shortly afterwards Mr. Barrow, Mr. L. Giers, and I extended the inspection. On the south of the beck referred to, there is an isolated conical hill, named Cat Nab, well-known to all who have visited Saltburn, and is a physiographical problem in itself. We searched this hill for a continuation of the beach, but being so completely overgrown and covered with soil, it was difficult to trace. The characteristic shells showing themselves at the expected horizon, satisfied us as to its existence there (2). The west side shows a clear section of drift owing to the undermining action of Brotton Beck, but no trace of the beach exists there (3), not having been deposited so far inland. Continuing the search towards Huntcliff it was again recognised at the same level (4). Here and there in it are dark looking patches containing sea-coal, similar to deposits frequently left in patches on the sea-beach of to-day. The existence of this raised beach at Saltburn only, on this part of the coast, indicates the extremely slow denuding action carried on at Saltburn. The rate of the sea's encroachment is trifling indeed when compared with the action of the sea upon other parts of the coast; take Robin Hood Bay for instance, where the sea's action is accurately marked, its inroad being 20 feet a year, three coast-guard flag-staffs having been washed away in 20 years, these having been placed 140 feet from the shore.

In leaving these notes for your consideration, I beg to express my thanks to T. E. Harrison, Esq., Engineer-in-Chief to the N. E. Railway, and to Chas. Harrison, Esq., for their kindness in placing, for my consultation, the numerous sections of borings, and specimens they have preserved at Newcastle.

NOTES ON THE CARBONIFEROUS ENTOMOSTRACA AND FORAMINIFERA OF THE NORTH YORKSHIRE SHALES. BY GEORGE ROBERT VINE (PL. XII.)

In a paper read before the *Geological and Polytechnic Society* on the Carboniferous Polyzoa of North Yorkshire (1881), I gave some account of the shales supplied to me by the late Mr. John Harker, of Richmond. In that paper I referred briefly to the Entomostraca and Foraminifera of the shales, and also to the unnamed series in Mr. Harker's private collection. I am not certain whether previous to our acquaintance Mr. Harker had made any great progress in his investigations, for as these organisms were his own speciality we did not have a very free correspondence respecting them. One of the conditions of our exchanges, was, that in searching the shales, I promised to give him specimens of all the Ostracoda and Foraminifera found in them, a condition I was bound in honour to respect, and had he lived, this paper would have remained unpublished. In return I had his promise of duplicates of his findings, whether Foraminifera, Ostracoda, or Polyzoa. On one occasion I asked him to give me the localities of his shales, but this I have never received; but in one of his letters, he says that his best locality was about ten miles from Richmond; but there were other localities, though not so rich in organic forms, which he promised to search for me. Had he lived, we should have worked together, as he promised me that I should have the material properly labled. As it is, my box of black muddy shale washings are marked only "Hurst," Richmond, a locality that I can give no other information of than this respecting it.* If, therefore, my northern friends would do their best to communicate to me the whereabouts of these shales, I shall be glad to give in return for their interest in my studies, something at least of corresponding value to assist them in theirs. Besides the shales, I have a few mounted forms given to me by way of exchange, and these are marked "Downholm" and "Ten Fathom Grit." These are some of the rarer species, specimens of which, however, are found also in the shales marked "Hurst." In Prof. T. Rupert Jones and Mr. James W. Kirkby's paper on *Palæozoic Bivalved Entomostraca*, No. VII., *Ann. and Mag. of Nat. Hist.*, July, 1866; the authors (p. 9) speak of a collection submitted to them by Mr. J. H. Barrow, M.A., of Settle, Yorkshire. I do not know the extent of that collection, and I am not aware that there are any more extensive references to the Carboniferous Ostracoda of North Yorkshire than are found in the various Carboniferous papers of these authors. In T. Rupert Jones' paper on the *Permian Ostracoda (Perm. Foss.*, by W. King, pp. 58–66), references are made to findings in the Yorkshire Permian rocks; and in Mr. T. Kirkby's paper on the *Permian Beds of South Yorkshire (Quart. Jour. Geol. Soc.*, March, 1865), the author refers to five species of Entomostraca found in the Shell Limestone, and in his remarks on the Permian fauna, Mr. Kirkby says, that four of the Entomostraca are German, and one, *Kirkbya Permiana*, J. and K. have Russian varieties. Since these papers were written, the ranges of several of the Permian forms are proved to be Carboniferous "recurrents," and our knowledge of the range in Carboniferous times of some of the species have been considerably enlarged by the discoveries of Mr. John Young, of the Hunterian Museum, Glasgow, and members of the *Scotch Geological Survey.* Very few, however, of the Carboniferous species range from the Silurian strata of this country. There is, therefore, very little difference in the generic character of the Permian and Carboniferous fauna of this type, but there is a considerable difference in the genera of the Carboniferous and of the Silurian eras. In the Silurian ages *Beyrichia*, *Primitia* and *Leperditia*, had a most extensive range, and there were a larger number of species of all the genera, but *Kirkbya* is very rare in the Silurian rocks. In the Carboniferous rocks these generic characteristics were reversed; *Kirkbya* were abundant, *Beyrichia* not so abundant in specific character, *Primitia* almost unknown, and *Leperditia* likewise few in number. It is impossible to make an exact comparison, because all the fossils being minute and difficult to identify, except by those who give to their investigations a patient earnestness, which is, alas, far from common in our matter-of-fact age. The present paper must not be looked upon then, as the work of a specialist, or in any way exhaustive. It may be possible that specialists will detect errors in the descriptions and identifications of the species enumerated below, but as these know full-well the difficulties that have to be encountered in work of this sort, I fear their criticism less than the frown of others, who have never yet attempted special labours. I feel certain that there are earnest youths in some of our Yorkshire Geological and Microscopical Societies, who are looking out for labour of some sort in the field, and ultimately in their homes. If there be such, I recommend to them the searching for, and then the systematic study of the more minute organic forms of our Yorkshire shales, and I feel confident that they will be amply rewarded in their researches. It is in the interest of these more especially that I write this paper, at the same time, I do not undervalue the work of the specialist, and I have identified to the best of my ability, and have given such descriptions of the species found in the shales as shall merit some approval of my labour even from them. I may say that in comparing my Yorkshire specimens, though I have been careful to look up the text of previous authors, I have been anxious also to see how far these agree with the same species found in the Northumberland, and also in the Scotch shales, a large suite of which are in my collection. In all my varied labours I am personally indebted to the continuous kindness of Mr. John Young, of Glasgow, who, on every occasion that I have sought his help by way of gift or loan of specimens, has systematically granted it, and information on all questions put to him has been unstintedly given.

---

* Mr. Wood, of Richmond supplied to Mr. Brady for his *Monograph* on Foraminifera, material from Hurst.

With regard to the Foraminifera of these shales, I find, in reference to Mr. Henry Bowman Brady's Monograph of the Carboniferous and Permian Foraminifera,* that my labours are anticipated. In that work, Mr. Brady specially cites two localities in Yorkshire from which he received material for his work. One of these is "Hurst," Yoredale, and the other "Downholm"; the material from each locality supplied by Mr. Wood, of Richmond. I was not aware, however, that Mr. Wood had devoted any share of his attention to the more minute fossils. Before him, Phillips described a species for which he founded the genus *Endothyra*, but very little progress was made till just before, and just after, the publication of Mr. Brady's Monograph. In this work, I find that the material of Hurst and Swaledale yielded sixteen species of Foraminifera, a list of which is given further on. As with other forms, so with these, the Scotch Geologists have systematically searched their shales, and the Scotch list is, consequently, by no means inconsiderable. Though not so fortunate as Mr. Brady and others, I have been successful in my findings of Foraminifera, as well as Entomostraca, but species of either group are far from abundant. Much good material, however, may be found and catalogued, but willing hands and keen eyes must be given to the work.

CRUSTACEA.

Sub. Class Entomostraca.

Order Ostracoda.—"Minute Crustaceans having the entire body enclosed in a shell or carapace, which is composed of two valves united along the back by a membrane. The valves are capable of being closed by an adductor muscle, the insertion of which is marked in the interior of each valve by a tubercle, pit, or group of spots, or by both spots and a pit. The branchia are attached to the posterior jaws, and there are only two or three pairs of feet, which subserve locomotion, but are not adapted for swimming." *

---

* Pal. Soc., London, 1876.

The Ostracoda are divided into several families, some of which are wholly made up of fossil genera, others are composed of both fossil and recent genera. They are as follows:—

Family I.—CYPRIDÆ: 12 Genera, one of which is BAIRDIA.
,, II.—CYTHERIDÆ: 17 Genera two of which contain only fossil species: THLIPSURA and CARBONIA.
,, III.—CYPRIDINADÆ: 9 Genera, three of which contain only fossil species: CYPRIDELLA, CYPRELLA. and ENTOMIS.
,, IV.—ENTOMOCONCHIDÆ: 2 Genera, one of which, ENTOMOCONCHIS, contain only fossil species.
,, V.—CONCHÆCIADÆ: 2 Genera.
,, VI.—POLYCOPIDÆ: 1 Genus.
,, VII.—CYTHERELLIDÆ: 3 Genera, two of which, CYTHERELLINA, and ÆCHMINA, contain only fossil species.
,, VIII.—LEPERDITIADÆ: 6 Genera, the whole of which contain fossil species only: LEPERDITIA, ISOCHILINA, PRIMITIA, BEYRICHIA, KIRKBYA, and MOOREA.† And the last family, so far as is at present known, contain only Palæozoic forms.

Family I. CYPRIDÆ.

Genus BAIRDIA, McCoy.

1844, Syn. Charact. Carb. Limst. Foss., Ireland.

"Carapace valves externally convex and smooth, sometimes finely pitted or spined, never ribbed or granulated. The hinge is simple, no bar or teeth similar to those of *Cythere* proper, being developed. *Bairdia* is characterised, as regards the carapace, by a somewhat similar formation of valves to that which obtains generally amongst the recent *Cyprides*, and partially in the *Candonæ*." Jones, Entomos. Cret. Formation, p. 22.‡

Professor McCoy described the genus very briefly, thus:— "shell elongate, fusiform, suddenly tapering at both ends; a very short proportion of the valve overlaps the abdominal margin."

Since these works were published a large number of recent and fossil forms have been discovered and described, and most important additions to our knowledge of the genus has been furnished by Professor G. S. Brady in the *Transactions of the Linnean* (Vol. XXVI.), and also of the *Zoological Societies* (Vol. X.) But to the Palæontological students the publication of a paper on the genus "*Bairdia*," by Professor T. Rupert Jones and Mr. Kirkby, is by far the most important. In this paper the authors give a brief history of the genus, a description of all the Carboniferous species found in Great Britain, and figures of the same (*Quart. Jour. Geol. Soc.* Nov. 1879). Altogether there are sixteen species of *Bairdia* in the Carboniferous rocks of Great Britain, two of which are doubtful.

---

* Nicholson Manual of Palæontology, Vol. I. p. 341, Ed. 1879,

† Bivalved Entomostraca, Prof. T. Rupert Jones, Monthly Microscopic Journal, Oct. 1870, Part I.

‡ Palæontographical Soc., 1849.

1. **BAIRDIA CURTA**, McCoy.

B. curtus, McCoy, 1844, *Syn. Char. Carb. Foss.*, p. 165.
Cythere (Bairdia) *curta*, Jones, 1849, King's *Perm. Foss.*, p. 61, pl. XVIII., fig. 3.
Bairdia curta, Jones & Kirkby, *Quart. Jour. Geol. Soc.*, Nov., 1879, p. 567, pl. XXVIII., figs. 1 to 8.

The examples of this species found in the shales are generally crushed, and correspond more closely with the example from Settle, given in pl. XXVIII., fig. 6, of Jones & Kirkby's paper (op. cit.) In this paper the authors state that there has been, with them, a considerable oscillation of opinion respecting this type. In their present remarks they agree to accept the type, and a pretty full description of the species is given. The examples found in the Yorkshire shales vary from about $\frac{1}{20}$ to $\frac{1}{12}$ of an inch in length.

Localities: Hurst, Richmond, Yorkshire. Localities given by J. & K. Wyebourne, Cumberland; Settle, Yorkshire: Steeraway, near Wellington, Salop.

2. **BAIRDIA SUBELONGATA**, Jones & Kirkby, (Pl. XII., figs. 1, and 1a.)

B. subelongata, Jones & Kirkby, *Quart. Jour. Geol. Soc.*, Nov., 1879, pl. XXX., figs. 1, 11, and 16.
B. subcylindinea (Munst.), Jones & Kirkby, 1867, *Trans. Geol. Soc. Glas.*, vol. II., p. 221.
B. subcylindrica, (Munst.), Armstrong & Young's *Cat. of Carb. Foss. of Western Scotland.*

Some of the specimens found in the locality given below correspond more closely with figs. 10 and 11 of pl. XXX. of the paper cited above, except that the posterior extremity is less pointed, otherwise the general contour of the specimens is similar to that figured by Jones & Kirkby. Another specimen shows a slight concavity on the ventral border.

The description given by the authors applies "to the more typical examples, which are always to be distinguished by their nearly straight backs, regularity of height, and well-rounded anterior ends." It is very rare, however, that the valves are found uncrushed. In the crushed specimens the posterior extremities are more pointed, a feature shown in some of the figures of the authors.

Localities: Richmond; and Limestone Shales, Hurst. Professor T. Rupert Jones and Mr. J. W. Kirkby give a very full list of the localities of this species from the Upper and Lower Limestones of Scotland, but the authors give no locality in England, and only one, Great Ormes Head, in Wales.

3? **Bairdia hisingeri**, Munster.

Cythere hisingeri, Munster, 1830, *Jahrb. f. Mineralogie*, p. 65.
Bairdia hisingeri Jones & Kirkby, 1865, *Ann. Mag. Nat. Hist.* ser. 3., vol. XV., p. 408, pl. XX., fig. 12.
Bairdin hisingeri Jones & Kirkby, *Quart. Jour. Geol. Soc.*. Nov., 1879, pl. XXIX., figs. 4-10, p. 570, pl. XXX., fig. 12.*

This species, though present in the Yorkshire shales, is not so fine nor so common as in some of the Scottish shales. I have only four fragments of the typical form, one of which shows the peculiar muscle spot. I have figured two other examples (figs. 2 and 2a), for the purpose of comparison. They are very similar in the general contour to those figured by Jones & Kirkby (pl. XXX., figs 12 and 13, *Quar. Jour. Geol. Soc.*, Nov., 1879), which the authors consider to represent an elongate form of *B. hisingeri*. "Fig. 12 is from Campsie," J. & K.

It is rather more elongate than the Yorkshire specimen, and it is less convex in the dorsal border, but the general outline is in many respects similar. Both the figures are magnified in the same proportion, 25 diameters, so that the differences between the two specimens may be noted.

Localities: Limestone shales: Hurst, Richmond. The localities in England given by Jones & Kirkby, are from Carb. Limest., River Wansbeck, Northumberland; and Wyebourne, Cumberland.

---

* See paper for other Synonyms.

4. **Bairdia plebeia**, Reuss. (Pl. XII., Figs. 3, 5, 5a.)

Bairdia plebeia, Reuss, 1854, Jahresbericht weltterau Gesellsch, 1854, p. 67, Fig. 5.

Bairdia plebeia, Kirkby, *Ann. Mag. Nat. Hist. Ser.* 3, vol. II., p. 324, Figs. 1 & 7.

Bairdia plebeia, Jones & Kirkby, *Quart. Jour. Geol. Soc.*, Nov. 1879.

In the last paper, several synonyms and special details are given.

The Yorkshire specimens of this form differ somewhat from the variations of the type furnished by Jones & Kirkby, in their most recent paper of the genus *Bairdia*, from the Carboniferous rocks of Britain. One of the specimens, in the pointing of the posterior extremity, makes a very near approach to some of my Scotch and Northumberland specimens of *B. submucronata* J. & K., but I think that the whole of the specimens figured, may be placed under *B. plebeia*, Reuss.

Formations: Permian and Carboniferous.

Localities: Hurst, Richmond; Messrs. Jones & Kirkby give Weardale, Durham; Wyebourne, Cumberland, and Settle, Yorkshire, as northern English localities; and they say that *B. plebeia* appears to have been the prevailing form of the genus during the upper Palæozoic periods." A large number of other localities are given by authors, both in Scotland, and a few in Wales. It is not very common, so far as I can judge, in the North Yorkshire shales.

5. **Bairdia brevis**, Jones & Kirkby (Pl. XII., Figs. 4a, 4a.)?

B. brevis, J. & K., 1867, *Trans. Geo. Soc.*, Glasgow, vol. II., p. 221.

B. brevis, J. & K., 1871, Armstrong & Young's *Cat. Carb. Foss. of West Scotland.*

B. brevis, J. & K., *Quart. Jour. Geo. Soc.*, November 1879, p. 575, pl. XXXI., Fig. 1 & 8.

In the last of these three papers, the authors' describe and figure, with its several variations, this delicate little species, "which, compared with its height, is the shortest species of the genus," known to them.

Localities: Hurst. The other English localities given by the authors, are Wyebourne, Cumberland; Weardale, Durham; Charterhouse, Somerset; and Scremerston, near Berwick-on-Tweed.

Family II.—CYTHERIDÆ.

Genus CYTHERE, Muller.

"Carapace closed, resembling a diminutive peach stone; valves unequal, irregularly ovate, sub-reniform, or sub-quadrangular, rarely smooth, often punctate or rugose; anterior hinge often has an external tubercle over the anterior tooth. The contact margin of the dorsal border of each valve, has an anterior and posterior hinge joint without a tooth and pit, or a ridge and furrow."—*Professor T. Rupert Jones.*

Species belonging to this genus are not numerous, and the specimens are very small. They are allied to undescribed forms found in the Carboniferous shales of Northumberland and Scotland. These bear MS. names by Professor T. Rupert Jones and Mr. J. W. Kirkby, whose brief notes in the *Transactions of the Geo. Soc.*, Glasgow, Vol. I., 1867, have enabled Mr. John Young, of the Hunterian Museum, and other workers, to name their specimens.

6. CYTHERE CORNIGERA, Jones & Kirkby, (Pl. XII., Figs. 9, 9a.)

This species may be easily recognised by the peculiar horn-like prolongation on the valves. In the figures, this horn-like character is not so apparent as when viewed under the microscope, because in drawing with the camera, these characters are not in one focus.

Localities: Hurst, Richmond. This is a common Scottish form in several localities.

7. CYTHERE CUNEOLA, Jones & Kirkby, (Pl. XII., Figs. 6, 6a, 7. ?)

This is a common form found in the shales. In all probability, fig. 8, may be placed with the same species.

Localities: Hurst, Richmond. Common in the Scottish shales.

There are still undescribed, two, if not three species, of *Cythera*, which, for the present, must remain in abeyance.

Fam. VIII. LEPERDITIÆDÆ.

Genus LEPERDITIA, Ronault.

This Genus was introduced, says Professor T. Rupert Jones, and instituted by M. Ronault, in 1851. "Its bivalve carapace is smooth, convex, horny in appearance, often brownish, sub-oblong, or somewhat semiovate in outline, longer than broad or high, inequilateral; posterior half broader; dorsal border straight, ventral border nearly semicircular."* This a very important genus, especially so for the identification in foreign localities of certain strata, and the horizons in which species have been found in this country and on the continent.

---

* Monthly Micro. Journal, T. R. Jones, Oct. 1870.

8. **Leperditia okeni**, Munster, (Pl. XII., Fig. 10 and 10a.)
Cythere Okeni, Munster, *Jahrbuch, f. M.*, 1830.
Notes on Palæozoic Bivalved Entomos. Jones & Kirkby, *Ann. Mag. Nat. Hist.* May, 1865, and Ibid Jany. 1875.

It will be impossible for the student to understand this species and its numerous varieties without referring to these papers. The specimens found in the shales seem to be referable to this species. The authors say of this form that the *Cythere Okeni* of Munster is a "*Leperditia* with the hinged or dorsal border usually a little over half the entire length, and the free, or ventral margin boldly rounded and somewhat oblique." There seems to be no other form whose general contour is so well marked, which has so wide a range as this. It is found in Russia, Nova Scotia, Germany, Belguim, and in the Upper and Lower Carb. strata throughout the British Isles. The specimens that I have are from two horizons, one set from the Richmond shales, and the other from the Ten Fathom Grit, Downholm, Yorkshire: the last was presented to me, unnamed, by the late Mr. Harker. There is in the shales, a small variety (Pl. XII., fig. 11), referred to in Messrs. Jones & Kirkby's papers, which seems to have had a variety of names. It is magnified in the same proportions (× 25), as the larger specimens. There are several other varieties of L. Okeni given by the authors, which, are not obtainable from the shales supplied to me. Seeing that the *L. Okeni* from the Ten Fathom Grit are so fine and perfect, the carapaces of my specimens being full and unbroken, it is quite possible that other species than this may be found in the same horizons if local workers would give attention to the search. In one of their papers (*Ann. Mag. Nat. Hist.*, July, 1866, p. 9), the authors refer to a collection of Entomostraca submitted to them for examination by Mr. J. H. Barrow, M.A., of Settle, Yorkshire. It may be that other collections are still extant in the neighbourhood of these shales, if so, I shall be glad to hear of them.

Genus KIRKBYA, Jones.

The Permian species belonging to this genus were originally described by Mr. T. Rupert Jones, in King's *Permian Fossils*, pp. 64

and 66. In that work *Kirkbya Permiana* Jones, received the name of *Dithyrocaris*. Since then, the discovery of a number of species in the Carboniferous rocks have necessitated a change in the name, and the present one is instituted in honour of Mr. Kirkby, the indefatigable coadjutor, with Mr. Jones in their united labours on the Carboniferous and Permian Entomostraca especially.

"The carapace valves are flattish, thick, oblong, impressed with a sub-central pit, and raised into ridges, some concentric with the margin, associated sometimes with longitudinal riblets, or wrinkles, and often accompanied by a reticulate ornament. In shape, the valves are sub-oblong, usually higher behind than before, the extremities are more or less rounded, but one often much more obliquely than the other; the dorsal border is straight, and its ends are sub-acute."—T. Rupert Jones' *Monthly Micro. Jour.*, Oct. 1870.

The valves of this genus in some respects resemble those of *Beyrichia*, "but the double and sometimes threefold ventral rims, and especially the sub-central pit and longitudinal riblets, distinguish them."—*Ibid.* I have not found more than three species in the shales of Hurst, and specimens of these are rare.

9. **Kirkbya permiana**, Jones, (Pl. XII.. figs. 12 and 12a.)
Dithyrocaris Permiana, Jones, *Permian Foss.*, p. 66, tab. XVIII., fig. 1, *a*, *b*, *c*, *d*.

The Carboniferous specimens of this species are much finer than the Permian, and their abundance in the shales of Scotland, and even in some of the Northumberland shales, enable the investigator to study the form with much greater advantage. But, so far as my own experience enables me to give an opinion, the species are very rare in the Yorkshire shales. I have only about five specimens in my collection, and these correspond so closely with the described species that I think there can be no doubt about the identity. The specimens figured (fig. 12) though magnified the same number of diameters, is smaller than fig. 1*a* *Perm. Foss.*, pl. XVIII., but rather broader than the cast 1*d* in the same plate. Some of the Yorkshire specimens are either crushed or broken; but the general form of the valves are sufficiently characteristic to enable the student to identify the species when found.*

---

* Since the above was written I have found more specimens of this *Kirkbya*, but I allow the original to stand, because, from my first specimen, the figures 12 and 12a are drawn, one magnified 50, the other 25 diameters.

Localities: Hurst, Yorkshire. I have the same species from Ridesdale: and Mr. Young gives the localities of Scotland, Orchard, Robroyston, Brockley.

10. KIRKBYA UMBONATA, D'Eichwald, (Pl. XII., fig. 13.)

Beyrichia umbonata, D'Eichwald, *Bulletin Soc. Imp. Nat. Moscou* 1857, p. 312, Leth. Ross., I.-V., 1859, p. 309, VII., p. 1348. pl. LII, fig. 10. See also Jones & Kirkby's paper, *Some Carb, Ostracoda from Russia, Ann. Mag. Nat. Hist.*, Jan., 1875, p. 53-4.

This is a much smaller form than the other, and it is marked with a central umbo. The ventral portion of the valves are thicker, and the dorsal border shorter. It is very rare in the shales.

Localities: Hurst, Richmond; D'Eichwald gives Sloboda (Carboniferous Shales); I have it in my Ridesdale collection, and Mr. Young cites Brockley, rather rare, and Craigenglen, Scotland.

11. KIRKBYA BIPARTITA, Jones and Kirkby. (Pl. XII., Fig. 14)

Transactions of the Geol. Soc. of Glasgow, 1877.

Catalogue of Western Scot. Foss., p. 44, 1856, Brit. Assoc. Cat.

This species is likewise rare in the shales. It is smaller than even *K. umbonata* and it is marked with two umbos, or tubercles in the valves. In the Yorkshire specimen these are somewhat depressed, but still sufficiently prominent to allow of identification. It is a beautiful little form, and the valves are ornamented as in some other forms of the genus with pitted impressions.

Localities: Hurst, Richmond, Ridesdale, Northumberland, Scotland; Orchard, " A rather rare form," J. Young: and Craigenglen.

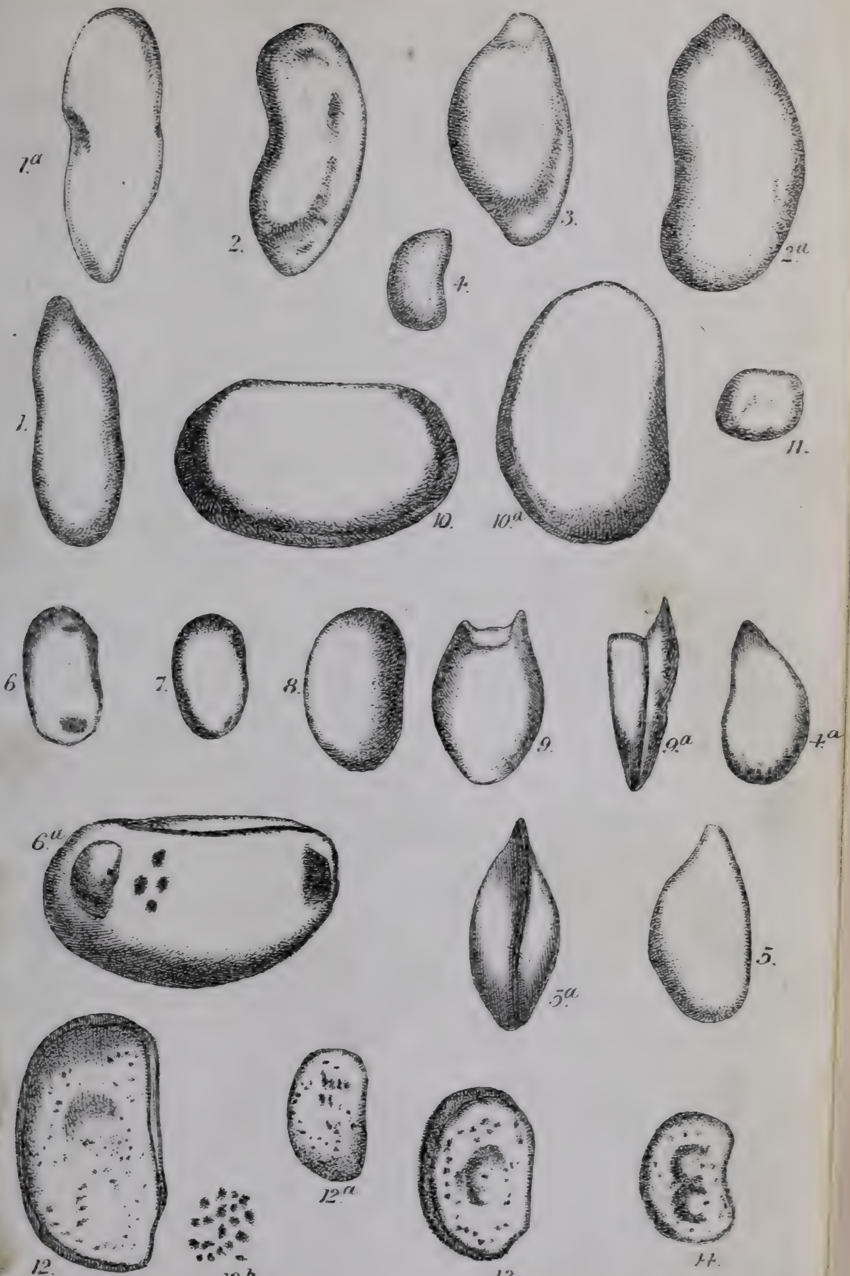
I have not found in any of the shales a single specimen of *Beyrichia* or *Entomis*. In the Scotch shales *Beyrichia* are generally distributed and *Entomis* is represented by a single species in the Carboniferous shales. The genus, however, has representatives also in the upper Silurian rocks.

There still remains a few forms of *Ostracoda* that I am not able as yet to identify; I am not certain, but I think that some of these may be referred to the genus *Cytherella*, but for the present I leave them.

The Foraminifera of the shales has been, as I have said previously, described by Mr. H. B. Brady, but as I have some of the forms in my collection it may be well to give a list, marking with an asterisk (*) the species found by me.

DESCRIPTION OF FIGURES, PLATE XII.

FIG. 1, 1*a*	Bairdia subelongata Jones & Kirkby.	× 25 dia.	
2, 2*a*	„ hisingeri Munster	× 25 „	
3	„ plebia Reuss.	× 25 „	
4, 4*a*	„ brevis? J. & K., or var.	× 25 „	
5	„ plebeia Reup.	× 25 „	
6	Cythera cuneola Jones & Kirkby	× 50 „	
6*a*	„ „	× 100 „	
7	„ „	× 50 „	
8	Cythea sp.	× 50 „	
9	„ cornigera Jones & Kirkby	× 50 „	
10, 10*a*	Leperditia Okeni Munster	× 25 „	10 fathoms, Grit Downholm
11	„ „	× 25 „	Small variety?
12	Kirkbya Permiana Jones	× 50 „	
12*a*	„ „ „	× 25 „	
13	„ umbonata D'Eichwald	× 50 „	
14	„ bipartite Jones & Kirkby	× 50 „	



YORKSHIRE ENTOMOSTRACA VINE

	HURST:—YOREDALE WITHOUT DEFINITE HORIZON.	Hurst.	Settle.	Cumberland.	Northum'ld	Durham Carb. Limst.	Durham Yored'le
	BAIRDIA, McCoy.						
1	curta, McCoy	+	+	+			
2	subelongata, J. & K.	+					
3	hisingeri, Munst ...	+		+	+		
4	plebeia, Reuss	+	+	+		+	+
5	brevis, J. & K.	+		+		+	
	CYTHERE, Muller.						
6	cornigera, J. & K. ...	+					
7	cuneola, J. & K. ...	+			+		
	„ Sp.	+					
	LEPERDITIA, Ronault.						
8	okeni, Munster	+					
8*a*	„ Small var. ...	+					
	KIRKBYA, Jones.						
9	permiana, Jones ...	+			+		
10	umbonata, D'Eichw ...	+			+		
11	bipartite, J. & K. ...	+					

FORAMINIFERA.

	HURST & DOWNHOLM:—YOREDALE WITHOUT DEFINITE HORIZON.	Hurst.	Downholm.
	TROCHAMMINA, Parker & Jones		
1*	centrifuga, Brady	+	+
2	anceps, Brady		+
	VALVULINA, D'Orbigny		
3*	palæotrochus, Ehrenb	+	+
4*	var. compressa, Brady	+	
5	youngi, Brady	+	
6	var. contraria, Brady	+	
	ENDOTHRYA, Phillips	+	+
7*	bowmani, Phillips	+	+
8	ammonoides, Brady	+	+
9*	globulus, D'Eichw	+	+
10*	radiata, Brady	+	+
11	macella, Brady	+	
	NODOSINELLA, Brady		
12*	concinna, Brady		+
13	linguloides, Brady	+	
	STACHEIA, Brady		
14*	marginulinoides, Brady	+	+
15*	fusiformis, Brady	+	
16*	papoides, Brady	+	+
17	acervalis, Brady	+	
18	congestre, Brady	+	+
	Not given in Brady's List—		
19*	Saccammina Carteri, Brady	+	

GLACIAL SECTIONS NEAR BRIDLINGTON. PART III. THE DRAINAGE SECTIONS. BY G. W. LAMPLUGH.

IN 1881 I described before this society, a cliff section for a short time exposed in building a new sea wall on the north side of Bridlington; and last year I undertook a similar section, lying to the south of the town.

These sections differed very considerably, and I then avowed myself unable to correlate them; but expressed a hope that I might be able to do so, by the aid of information which might be gleaned whilst drainage works were being carried out in the town. These works have now been completed, and I desire on this occasion to lay before you the results obtained.

During the progress of the work I made sketch-sections and notes of the whole length,—about 5½ miles—and have since worked these in on the Ordnance plan of five feet to the mile; but as this is, of course, too large for publication, and there is sufficient similarity about the sections, I have reduced those which are most representative, following the main drainage lines to a horizontal scale* of eighteen inches to the mile. These will, with the aid of a few notes on the unpublished sections, I think, suffice to show the structure and arrangement of the beds.

I have also prepared a ground plan of the town and its immediate neighbourhood, which will show the levels and general run of the beds; and will help me to express my views on their origin.

The Sections. The deepest drains were those near the outfall across the harbour, where a depth of 22ft. was reached; the shallowest were about 5ft. The average depth of the drains was 10ft.

The following beds were cut through:—

Top soil, made ground and old marsh ground, sometimes of

---

*The length of the sections as compared with their depth, has compelled me to depart from my usual practice of drawing to natural scale, and the vertical scale is in this case exaggerated three times, a fact to be borne in mind when comparing this with former sections.

GLACIAL SECTIONS NEAR BRIDLINGTON. PART III.

THE DRAINAGE SECTIONS.

Proc York Geol and Polyt Soc NS Vol VIII, Pl XIII

SCALE.

Horizontal: Eighteen Inches to One Mile
Vertical: – X 3 – One Inch to Sixty Feet (same scale as in Pls I & II.)

Fig I. Section from the Harbour at Bridlington Quay across Clough Bridge through Queen Street and along Promenade & Flambro' Road to the Railway Arch

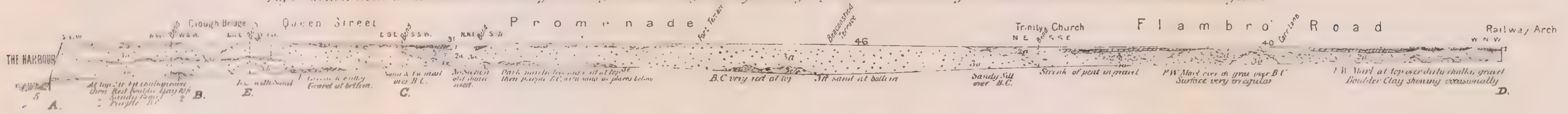

THE HARBOUR
S.S.W.
N.W. Bend W.S.W.
Clough Bridge
Queen Street
E.S.E. Bend S.S.W.
31
N.N.E. Bend S.W.
Promenade
Fort Terrace
Beaconsfield Terrace
46
Trinity Church
N.E. Bend S.S.E.
Flambro' Road
40
Carr Lane
Railway Arch
W.N.W.
3a
3c
3b
2
2a
5
At top 2 to 4 ft chalky gravel then Red Boulder Clay with Sandy Gravel & Purple B.C.
Ice with Sand
Gravel & chalky Gravel at bottom
Sand & F.W. marl over B.C.
No Section old drain used
Dark marls, ... at top then purple B.C. with sand in places below
B.C very red at top
Silt sand at bottom
Sandy Silt over B.C.
Streak of peat in gravel
F.W. Marl over ch. grav. over B.C. Surface very irregular
F.W. Marl at top over dirty chalky gravel Boulder Clay showing occasionally
A.
B.
E.
C.
D.

Fig II. Section from corner of Queen Street, Bridlington Quay along Quay Road and Saint Johns Street, to corner of High Street, Bridlington

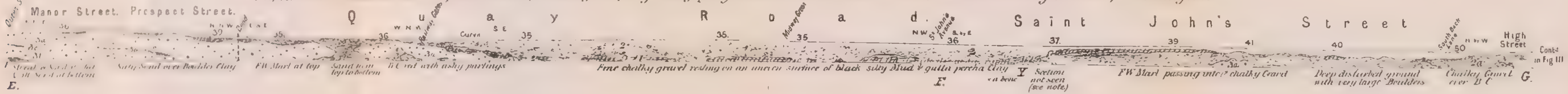


Fig III (continuation of Fig 2.) Kirkgate, to top of Pinfold St. Bridlington

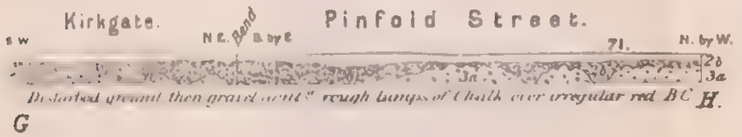

Kirkgate.
Pinfold Street.
S.W.
N.E. Bend S by E
71.
N. by W.
2b
3a
Disturbed ground then gravel with rough lumps of Chalk over irregular red B.C.
G
H.

Fig IV. Section along Hilderthorpe Road to corner of Clough Bridge

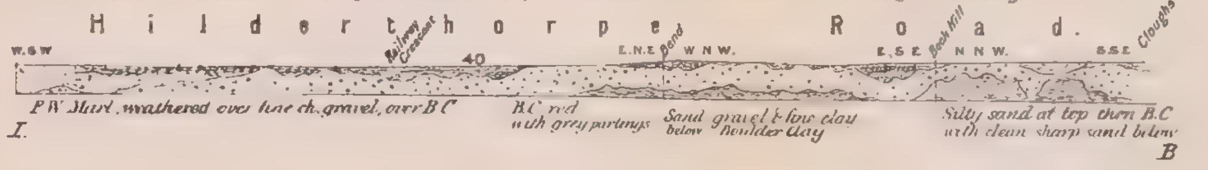
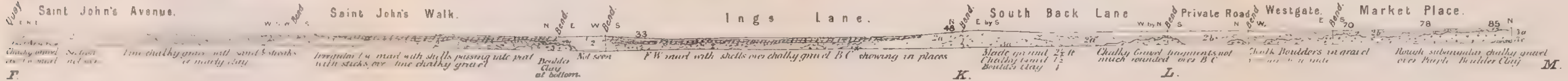

Hilderthorpe Road.
Railway Crescent
Back Hill
Clough's
W.S.W.
40
E.N.E. Bend W.N.W.
E.S.E. Bend N.N.W.
S.S.E.
F.W. Marl, weathered over fine ch. gravel, over B.C.
B.C. red with grey partings
Sand gravel & fine clay below Boulder Clay
Silty sand at top then B.C. with clean sharp sand below
I.
B

Fig V. Section from Quay Road through St Johns Avenue, St Johns Walk, Ings Lane, South Back Lane and Westgate to the top of Market Place, Bridlington


Quay Road
Saint John's Avenue.
Saint John's Walk.
Ings Lane.
South Back Lane
Private Road
Westgate.
Market Place.
E.N.E.
W.N.W. Bend S
N. Bend E
W. Bend S
33
48 Bend E by S
W by N Bend S
N. Bend W.
E. Bend S
70
78
85
N
2
2b
3a
Chalky gravel over marl
No Section
Fine chalky gravel with sand & streaks of marly clay
Irregular F.W. marl with shells passing into peat with sticks over fine chalky gravel
Boulder Clay at bottom.
Not seen
F.W. marl with shells over chalky gravel B.C. showing in places
Made ground 2½ ft Chalky Gravel 7½ Boulder Clay 1
Chalky Gravel fragments not much rounded over B.C.
Chalk Boulders in gravel
Rough subangular chalky gravel over Purple Boulder Clay
F.
K.
L.
M.

EXPLANATION.

Top Soil and Made Ground
1 Fresh water Marls = Nº 1 of Pls I & II.
2. The "Gypsey Gravel" (recent fresh water) = Nº 2 of Pl II. Fig 2.
2a Low level Sand Gravel and Silt = Nº 2 of Pl I & Nº 2 of Pl II Fig 1 (?)
2b High level Gravel = Nº 2a of Pl II & Sewerby Gravel of Pl I (?)

"The Bridlington Series"

3a Upper Purple (?) Boulder Clay = Nº 3a of Pls I & II
3c Intercalatury Sand & Gravel = Nº 2a of Pl I & 3c of Pl II
3b. Lower Purple Boulder Clay = Nº 3b of Pls I & II.
4 Laminated Clay of Pls I & II absent from these Sections
5 Basement Boulder Clay = Nº 5 of Pls I & II.

The small figures above the Sections are levels of Surface in feet above Ordnance Datum
The large Capitals refer to points marked on Ground Plan and in text

considerable thickness in the more ancient parts of the town: 7ft. in Church Green.

1 *and* 2. Fresh-water marls (1); sands and gravels—*the Gypsey Gravel* (2). The fine chalky gravel, No. 2 of this section, seems to be roughly contemporaneous with, at least, some part of the fresh-water marls.

2*a*. Gravel, sand and silt; older than the fresh-water marls, but closely connected with them, and certainly of fresh-water origin.

2*b*. High level gravel, sand and silt; this I believe to be also of fresh-water origin, and equivalent of the *Sewerby Gravels* of Mr. Dakyns, on the north of the town; and the *Hilderthorpe Sands*, Phillip's *Warp Series*, on the south.

It is with these gravels, 2, 2*a*, and 2*b*, that I would specially deal in this paper.

3*a*. Upper Purple (?) Boulder Clay.

3*b*. Intermittent Sand and Gravel.

3*c*. Lower Purple Boulder Clay.

These beds are of the same character as in the former sections.

4. *(Laminated Clay of Parts I. and II. absent).*

5. 'Basement' Boulder Clay; only cut into for a short distance in the deepest drains towards the Harbour.

Sections not figured. The following brief extract from my notes of the lines of section not included in the figures in plate I. may be of use.

Marton Road, Bridlington. Rough chalky gravel and sand, 2*b*, over Boulder Clay with irregular surface; Boulder Clay comes to top in places. Depth 6ft.

Nungate, Bridlington. Silty sand at top, then chalky gravel resting on a very irregular surface of Boulder clay; depth about 9ft.

South Back Lane, Bridlington. At top, deep soil with broken bones, over chalky gravel, over Red Boulder clay; about 8ft.

Church Green, Bridlington. Deep black humus with sticks and bones (?) over chalky gravel. The humus, a kind of disturbed earth, but towards the bottom seems to be stratified; probably an old bog; 9ft.

Wellington Road to Promenade, Bridlington Quay. In Wellington

Road, clayey sand with gravel streaks, sometimes to bottom. 12-14ft., but often on boulder clay; beyond Tenny Lane, red boulder clay with ashy partings comes to surface; approaching Promenade, fresh-water marl and gravelly sand come on above; 6 to 14ft.

Carr Lane and Sewerby Crescent, Bridlington Quay. Fresh-water marl intermittent, over chalky gravel; over boulder clay in places; 4 to 10ft.

Chapel Street, Bridlington Quay. Boulder clay generally to top, but a few hollows filled with marly wash; about 10ft.

Grundale Terrace, Hilderthorpe. Fine chalky gravel with sand, over boulder clay; about 7ft.

Detailed Description. Commencing at the top, a noteworthy feature in certain places, especially in the old town of Bridlington; in the neighbourhood of the church, where an old priory once stood, is the depth of the top soil and disturbed ground, consisting of black vegetable humus with many fragmentary bones apparently of domestic animals. This has evidently formed an old marsh in wet times; and in Saint John Street, at the point marked Z on the ground plan, a number of big drift-boulders were found, which seem to have formed stepping stones. In other places, rough pavements made of similar material were cut through; and in Westgate, an old road was uncovered three feet below the present surface; it was overlaid by 18 inches of silty marl.

The Fresh-water Marls (No. 1). These marls occupy the low-lying parts of the town, and do not occur at higher elevations than about 40ft. above the Ordnance Datum line, though there is occasionally a loose silty wash above the lower beds at slightly higher levels. This wash probably indicates the margin of the shallow lake in which the marls were formed, whose borders would, from the character of the underlying beds, be subject to great fluctuations according to season.

In the sections between Bridlington and Quay the marls seem to pass into, or under,* the fine chalky gravel, No. 2, which reaches down to the banks of the Gypsey Race, and forms a valley-gravel extending for some distance on both sides of that stream.

---

* This point is left doubtful by an unfortunate hiatus in my sections, a few yards of trench near Y in Plate I. Fig. 2, having been filled in before I could examine it; the contractor informed me the marl here *rose* from the bottom of the drain, as shown by the dotted lines, but I do not feel certain on the matter.

This gravel may be traced along the bottom of the valley in following the stream up into the Wolds,* being especially well developed at Boynton, about two miles west of Bridlington. It is everywhere far wider and reaches higher levels than is possible for the present water. The same chalky gravel appears to show in the the cliff section south of Bridlington, as described and figured in part II. of this paper. (Fig. 2.)

I should say the formation of this gravel went on simultaneously with that of the marls, so that they are on the whole roughly contemporaneous. There is confirmatory evidence of this, in that the marls generally have a thin sprinkling of small chalky pebbles in them.

The Low-level Sand, Gravel and Silt. (2a.) Where the marls exist, they occasionally rest directly on the Purple Boulder Clay if that uneven bed comes near the surface; but oftener they are underlaid by the beds marked *2a* in the sections. These are decidedly older than the marls, but closely connected with them, and undoubtedly of fresh-water origin. They vary in character, but often take the form of sandy or silty gravel with much chalk in small sub-angular fragments. Their junction with the Purple Clay often shows the peculiarities noticed in the two former parts of this paper, the clay intruding into the gravel in long 'tongues.'†

Near Trinity Church patches of peaty stuff occurred in this gravel, and I have also the skull and horn cores of a sheep (?) said to have been obtained from it.

The High-level Gravel, Sand and Silt. (2b.) On the boulder-clay slopes of Old Bridlington the low-level gravel, *2a*, seems to rise and pass, without break, into a very rough gravel of rather similar lithological character, which, from its position, appearance, and direction, I should say represents the high-level "Sewerby Gravels" of Mr. Dakyns.*

---

* See Mr. C. Fox Strangways in Survey Memoir "On Oolitic and Cretaceous Rocks South of Scarbro'," p. 37, for account of Wold Valley Gravels.

† See also Mr. J. R. Mortimer in "Sections of Drift in Drainage Works, at Driffield" (Proc. Yorks. Geol. and Polyt. Soc., 1881), for similar appearances there.

The distribution of this gravel is very irregular, but it is rarely absent from the sections which rise above the 50ft. contour line. It varies considerably in roughness, being, in places, full of large sub-angular lumps of chalk such as one might find in the bed of a swift stream; whilst in others the pebbles are small, though never very well rounded. Speaking generally, its roughness increases very rapidly as we pass up the slopes on the north side of Bridlington, and decreases in the opposite direction, becoming, at the same time more sandy; from which I should infer that the bare chalk slopes in the immediate neighbourhood have supplied the chalk contained in it.

The eastern extension of the gravel towards Sewerby is not well marked till we reach the ground shown in the north-east corner of the ground plan; but from this point it may be traced continuously. There is a good section in a gravel pit behind the farm known as *Sands House*, where the gravel is very coarse and contains many large foreign pebbles, as well as much chalk, the former being no doubt derived from the erosion of the Purple Clay on which the gravel rests.

Still going east we had another fine section of the gravel in the ballast-pit in the railway cutting near Sewerby Gate-house, but this is now closed and the banks sloped. The bare chalk surface is seen in the cutting about 500 yards further north, and the gravel seems to pass down from this, and overlap the feather-edge of the Purple Clay. The gravel here forms a well-defined ridge running east and west, and must be of considerable thickness. From this point the surface slopes gradually down to the cliff, where the gravels are seen in continuous section.† They may be traced along the headland towards Flambro' Dykes, thinning out rapidly and decreasing in roughness, and finally disappearing from the cliff two fields west of the Dykes Farm. They appear to die out against or thin out over, a gravel containing very little chalk.

---

* Mr. J. R. Dakyns, Proc. Yorks. Geol. and Polyt. Soc., 1879, p. 123, and 1880, p. 246.

† See Mr. J. R. Dakyns, in papers cited above.

In tracing the gravels either eastward in this direction, or southward through the town in the drainage sections, the way in which they gradually decrease in roughness as we leave the exposed chalk surface is very noticeable, and I would again call attention to it.

The bearing of these facts I shall consider in the concluding portion of this paper, in dealing with the gravels as a whole.

The Purple Boulder Clay. The description of this clay given in part II of this paper would apply to its character in these sections also. It occurs in two well-marked divisions separated by a very irregular and intermittent bed of sand or sandy gravel *(3c)*. The upper part *(3a)* in many of the sections showed all the characteristics of the "Hessle Clay" of Mr. S. V. Wood, being quite red in colour and having ashy coloured partings down its joint planes, evidently the result of weathering; but whether it is really the same as the top red Boulder Clay of Holderness, and of Flambro' Head, I have not yet been able to determine. Of one thing I am certain, that this upper division in the town is the same as that marked 3*a* in the cliff sections already published; which has always been considered as the Purple Boulder Clay.

The intercalary sand and gravel, which rose in some of the sections to a considerable thickness for a short distance but always rapidly sank and thinned again, seems to have suffered great erosion, and to have been cut down into and often completely removed during the formation of the overlying Boulder Clay. It consists in some places of pure sand, in others of roughish gravel, but oftener an admixture of sand and gravel.

I consider it to be the same bed as the gravel in the cliff section to the north (marked 2*a* in part I), and as the stratified band with intermittent sand to the south of the town (marked 3*c* in part II. of this paper).

The lower division of the Purple Clay requires no special comment, being identical in character with that of the sections already described.

The Basement Boulder Clay. This division was only touched in the deepest drains just before reaching the Harbour, but was cut into in carrying the outfall pipes across the Harbour and over the South Sands to low-water mark. It was of the same patchy nature as in the former sections, the cuttings in the Harbour showing a large proportion of sandy wash in irregular masses, not however, containing shells, save as worn fragments.

The Laminated Clay, No. 4 of former sections, true to its rule of not attempting to rise above a certain level—that of high tide—was not found in these sections, except on the beach.

Concluding Notes.—Following the plan of my former papers, I will now briefly record the deductions I have drawn from the facts observed: also as in former years, concentrating attention chiefly on one point, which on this occasion shall be *The Freshwater Gravels.*

I commenced working on the Sewerby Gravels, as on the Hilderthorpe Sands, with the idea that they were marine, but during the course of my investigations the conclusion has been forced upon me that they are freshwater; and the knowledge gathered from the drains has strengthened me in this view.

In the absence of contemporaneous organic remains in either bed there is no direct proof of this, but the indirect evidence is strong.

Before dealing with this, it will be well to show on what grounds I conclude that the Sewerby Gravels, the Bridlington High-level Gravels, and the Hilderthorpe Sands are lateral extensions of one and the same bed.

The connection between the Bridlington and Sewerby Gravels has already been partially traced. Their general appearance; their respective positions relative to the Boulder Clay and Chalk; the levels at which they occur; the character of the Chalk-fragments contained in them; and the way their pebbles decrease in size as we leave the steep chalk slopes, are all strong proofs of their intimate relationship; and that the Hilderthorpe Sands form their southerly extension rests on evidence equally convincing.

The relative position of the Sands to the Boulder Clay below, and to the marls and fine chalky-gravel above; the tendency of the sands and clays to pass into, or include streaks of gravel with small flat pebbles of chalk; the rapid attenuation of the series southward, and its tendency to become finer in that direction, so that at Wilsthorpe only a few feet of finely-bedded warp-clay is seen; the fact that an actual passage from sandy-gravel to sand can be seen in the cliff immediately south of the town (as shown in Part II., Fig. 1, at C.), taken in connection with the strong tendency of the Sewerby and Bridlington Gravels to change into finer material as we leave the chalk, satisfies me on this point.

And there is yet the additional evidence of the isolated outliers standing out here and there above the level of the freshwater marls and lower gravels, forming as it were, detached links of the once continuous chain. One such link is the oblong knoll of sandy gravel (marked Y on the ground-plan) near where the Gypsey Race passes under the railway; another, the silty sand deposited on the crest of the Boulder Clay slope on which Belle Vue Terrace stands; and others in the broken ridge of sand in Hilderthorpe. There is abundant proof that these beds have suffered severe erosion during the deposition of the later gravels;* and from the character both of the Low-level gravel (2*a*), and the more recent stream-gravel (2) I should say that these are, more or less, re-arrangements of the older series.

My view of the origin of all these gravels is, that they are the product of fresh-water issuing chiefly from the Main Wold Valley, which debouches into the low ground of Holderness, close to the town of Bridlington, as may be seen by the contour lines on the ground-plan.

Without entering into many details of the physical features of the district, which I shall presume to be known to those who will find matter to interest them in this paper, I may explain that this valley reaches right into the very heart of the Wolds, and, with its branches and feeders, has a drainage area of about 86 square miles.† Its course upward from Bridlington to Rudstone, a distance of about 6 miles, is nearly due west, but here the main valley swerves round to the north, pursuing that direction for 3 miles, as far as North Burton, where it again curves west, continuing on the whole in this direction to its head beyond Helperthorpe, a total length of about 21 miles. The hills which surround it rise to a height of from 200 to 600 feet above the sea level.

---

* See last year's paper.

† A rough estimate only.

Nearly the whole of its drainage area is bare chalk, and the porous nature of that rock which absorbs all the rain that falls on it and prevents surface drainage, causes the quantity of water now coming down the valley to be extremely insignificant. The upper half of the valley is practically dry; whilst the stream, the Gypsey Race, which commences at Wold Newton and flows to Bridlington is, in ordinary winters, a mere brook, and in dry seasons ceases to flow at all.

But that this has not always been the condition of things is clearly shown, not only by the thick and widespread gravels which now cover the bottom of the valley, but, indeed, by the very fact that there is a valley at all, for its features show that it must be in some degree the result of running water, and at present there is absolutely no erosion (save chemical) going on in it, the Gypsey now everywhere flowing over its old gravel and nowhere over bare chalk, the water in it barely sufficing to keep its own channel clear. Yet if we could imagine that, from one cause or another, the surface of the chalk were rendered impervious so as to shed the moisture descending on it, the 'dry bones' of the valley would live again; and we should, even with the present rainfall, soon have a respectable river coursing along its bottom and swooping down into the Holderness country in the open light of day, instead of, as at present passing silently underground into the sea.

At one time I was inclined to believe that the chalk might have been rendered impervious during glacial times by a waterproof covering of drift-clays, of which it might since have been denuded. But the evidence for the passage of ice over the higher Wolds is so slight, and on the other hand, the proofs of an ice-flow, glacier or floating ice, skirting the coast, partially over-riding the headland of Flambro', and then passing along the inner edge of the Wold, are so strong, that I am now disinclined to entertain any view which necessitates the complete submergence of the district beneath land-ice.

And another possible explanation has occurred to me, which is plausible enough for our purpose, and enables us to dispense with the services of the dubious ice sheet.

It is this.

Though chalk when dry and open can swallow any amount of water, yet when saturated and frozen, and its joints choked with ice, it sheds water freely, as may occasionally be seen during melting of the snow on the Wolds. And if, during late glacial times the chalk were not buried beneath the ice, we may be sure it would not escape the effects of the prevalent low temperature, so that the above-mentioned conditions would not be wanting. Therefore we may, if we like, assume a more or less impervious subsoil of frozen chalk over the whole of the Wold area; and thus, with the aid of the wet weather always allowed to theorists about this time, obtain a volume of fresh water in the valley amply sufficient for our requirements.

The origin of the Wold dales and the occasional presence of terraced gravels along their flanks may be brought under the direct action of the same agency.

Now let us return to the mouth of the valley, and consider the effect of the altered conditions there.

From the head of the valley to its embouchure at Bridlington, there is a steady and tolerably steep gradient, but when once the chalk slopes are passed, and the northern end of the Holderness district fairly entered, the fall is absolutely lost, and there is at present drift ground actually higher than the valley bottom, between it and the sea. The present stream has cut through this, and thus formed the deep channel which separates Bridlington Quay from Hilderthorpe, by this means reaching the harbour. This channel has evidently been cut quite recently, as the stream now flows for the last half mile of its course through a mere trench in a ridge of boulder clay, and abandons its old gravel-flat near the corner of Piercy Lane. This gravel, marking out the old course of the drainage, is deflected to the south west, as shown on the ground-plan, and spreads out, often covered by the later marls and peat, over the whole of the low-lying ground in the neighbourhood of Bessingby and Wilsthorpe, its outer edge reaching the cliff near Auburn as shown in Fig. 2 of last years sections. Thence its extension southward may be traced past Fraisthorpe to Barmston, where it seems to leave the coast; and, still hugging, more or less closely, the inner edge of the Wolds, pass inland by Ulrome and Beeford, the waters at that period probably finally discharging themselves like the rest of the drainage of East Yorkshire, into the Humber Estuary.

This seems to have been the course of the Gypsey water during the comparatively recent times indicated by the fine chalky gravel No. 2 of the sections. At this time the head issuing from the wolds was great enough to carry the flood over a country almost level, the fall between Bridlington and the Humber not being more than about 25ft., though the level of the land may have stood somewhat higher at that time. But as the volume of water decreased, so that circulation through a wide spread body of shallow water could no longer be sustained, marls and peats commenced to form in the lower portions of the flooded country, in part contemporaneously with the gravels in the direct streamway, and their deposition, in some places, did not cease till the time of artificial drainage in Holderness.

Prior to the period of this, the "Gypsey Gravel," the stream from the mouth of the valley seems to have been strong enough to penetrate further east before being deflected, sweeping past old Bridlington but curving round southward before reaching Sewerby, its outer limits and curve being nearly coincident with the 50ft. contour line. Higher ground standing where now the sea is, a continuation south-eastward of Potters Hill, perhaps, seems then to have deflected the stream along a course nearly due south, causing it to pass to what is now the seaward of Bridlington Quay, and then south-eastward across towards Auburn, and so inland, as indicated in part by the dotted lines in the plan. The stream would thus sweep round the knoll of boulder clay on which the Quay stands; and evidence of its course is found in the gravel *(No. 2 of Part I)*, whose feather edge may be traced along the top of the North Cliff into the town. Towards the harbour this thickens considerably; and I think that where the harbour now stands, once formed part of the hollow, containing gravel and freshwater marl, which is seen in the cliff section just beyond the South Pier (shown in Part II., fig. 1); and in this way there may have been a connection with the similar hollow seen in section near Sands Cottage on the north of the town.

It is thus that I would account for *the low level gravels*, 2*a*, of the sections.

There remains now to be considered the high-level series of Bridlington and Sewerby, with their supposed extension, the Hilderthorpe Sands.

We may safely assume that the formation of these beds followed very closely on glacial times, if indeed, not themselves actually glacial, for it is an open question whether they were not, in part at least, contemporaneous with the Boulder Clay.* This allows us as the period for their formation the time of storms and melting ice, when the yield of water from the valley would attain its maximum, and the whole of the low country might be flooded to a considerable depth; for the dam of Glacial Clays across the mouth of the valley at that time reached higher levels than at present in its extension seaward, and not only stemmed back the flood, but also may have diverted into it part of the drainage of the Bempton Valley.

The effect of this would be to create a wide lake with strong currents, between the Wold slope and the coastwise glacial bar, in which the swift flood-waters, stayed in their course, would rapidly throw down their burden in the order that we find it, the rough sub-angular gravels at the lower levels near the mouth of the valley where the torrent was first stayed *(the Bridlington Gravels)*, the smaller gravel carried forward and banked against the gentle slopes of Boulder Clay at the curve† *(the Sewerby Gravels)*, and the finer material deposited from the eddying waters after sweeping into the lake,‡ as crossbedded and ripple-marked sands and warps *(the Hilderthorpe Sands)*.

---

* Mr. J. R. Dakyns supra. cit.

† For the supposed effect of the ice-laden currents on the slopes near the curve, see conclusion to Part I. of this paper in *Yorks. Geol. and Polyt. Soc.*, 1881, p. 395, et seq.

‡ I should expect the same results if the level of the sea at this time stood high enough to form an estuary at this spot, but the evidence is against the sea being higher than at present and favours the view that it was lower.

I am by no means certain that the ice which formed the top red clay of Flambro' Head had entirely disappeared at this time. Indeed, I am inclined to think that its presence as a glacier overlapping the headland and stretching into Bridlington Bay may have aided in the deflection of the valley-floods, and have also helped to swell them, not only by waters poured down the Bempton Valley, but also by streams issuing directly from the ice and coursing south-west. In support of this I would cite the chalkless gravel which is seen to pass under the Sewerby Gravel in the cliff section opposite Sewerby Park, and the similar gravels seen in many places on The Head, which are evidently the result of the washing of Boulder Clay material. I am inclined to think the gravel, 2*b* of Part II., is of the same age as these chalkless gravels and has had a similar origin.

I think the term "*Bridlington Series*" might fitly be applied to cover the Bridlington and Sewerby Gravels and the Hilderthorpe Sands, to include also the low level gravels marked 2*a* in these sections, whose formation is so analogous to that of the older beds, of which they probably formed a direct continuation in time, that it is not necessary to separate them.

I would also suggest the term *Gypsey Gravel* for the more recent gravels, No. 2 of these sections, as their history is, beyond all doubt, closely connected with that of the stream which bears the name.

In conclusion, the picture presented to my imagination of the condition of things in the neighbourhood during depositions of *the Bridlington Series*, is of bleak frozen chalk wolds, silent and deserted, and deeply covered by snow in winter, and in summer streaked and drenched with melting snow and muddy chalk *dêtritus*, and of dales, sometimes ice-bound, sometimes held by rills and streams and floods of icy water sweeping out into the low ground with swift floe-laden currents, submerging much of the wide uneven plain which then stretched far out into the present bed of the North Sea, and reducing it to a state resembling the descriptions we have of the Siberian *tundras* in flood time.

Later, with less copious streams, I picture Holderness as a "mershe countree;"—a place of lakes, and bogs, and ponds innumerable, with sluggish waters meandering amongst island knolls and ridges covered with forest trees or tangled brushwood and reeds—a place, indeed, fitly justifying the opinion of a rueful farmer of these parts, who roundly holds that "'twas never made nor meant for aught but a place to shoot wild-duck in, and it's man's own fault if he wont believe it." This condition of things I suppose to have extended up to the historic period.

This for what it is worth, for I know well enough the danger of theorising on too narrow a basis; and do not profess to have carried on a close investigation save in my own immediate neighbourhood, and therefore state my conclusions subject to the correction or confirmation of those whose work and experience are greater than mine. But, with this caution, I think no harm can come from this tentative statement of a theory which conveniently covers all the facts known to me, and I should like to hear if similar explanations could be given in other localities whose physical features resemble those of this neighbourhood.

I may mention that in considering the origin of our East Yorkshire Boulder Clays it has seemed to me that the land-ice theory only partially succeeds in explaining the facts. Not, indeed, that I have any very definite views on the subject, only, in the course of my work, I have found myself falling into the habit of thinking or speaking of this, or that, as the product of land-ice, without having a very clear notion of the properties and capabilities of that curious body.

In fact, now-a-days, an ice-sheet has become a sort of geological comfort and one can hardly do without it; but somehow, in this neighbourhood, when I have invoked its aid, it has persisted in doing the things it ought not to have done, and leaving undone the things it ought to have done in so irritating a manner that I have ceased to place much confidence in it. Of course a good glacier under perfect control in a high mountainous country is extremely serviceable and can be held accountable for much; but ice-sheets sprawling out over great flat plains, like that now occupied, save for the little corner of Holderness by the North Sea, seem to do much as they like, and refuse to give any reasonable explanation of their conduct.

Might one expect to find traces of *Kryokonite* in any of our glacial clays?

In the first part of this paper I stated my views on the subject of the intermingling of these gravels with the Purple Boulder Clay; in the second part, on the origin of the stratified band and intercalary sand and gravel in the Purple Clay; in the *Geological Magazine*, for September, 1879, I have described the Laminated Clay; in the same magazine for December, 1881, and possibly also in a forthcoming number of the *Quart. Jour. Geol. Soc.*, I have dealt with the Basement Boulder Clay and its included fragments of beds; and with the present paper it is probable that this series will close. Not from want of matter, for there are problems enough in this, as in most neighbourhoods, to suffice for many lives, but from the current of events which will separate me from my work.

I have to thank Messrs. Dobb & Gummer, the contractors for the drainage works, for the facilities and information they have so courteously rendered me during the course of the work; and J. S. Moloney, Esq., C.E., for his kind advice and aid in preparing the plan and sections.

ON THE SHELL MOUNDS OR KITCHEN MIDDENS AT SPURN POINT.

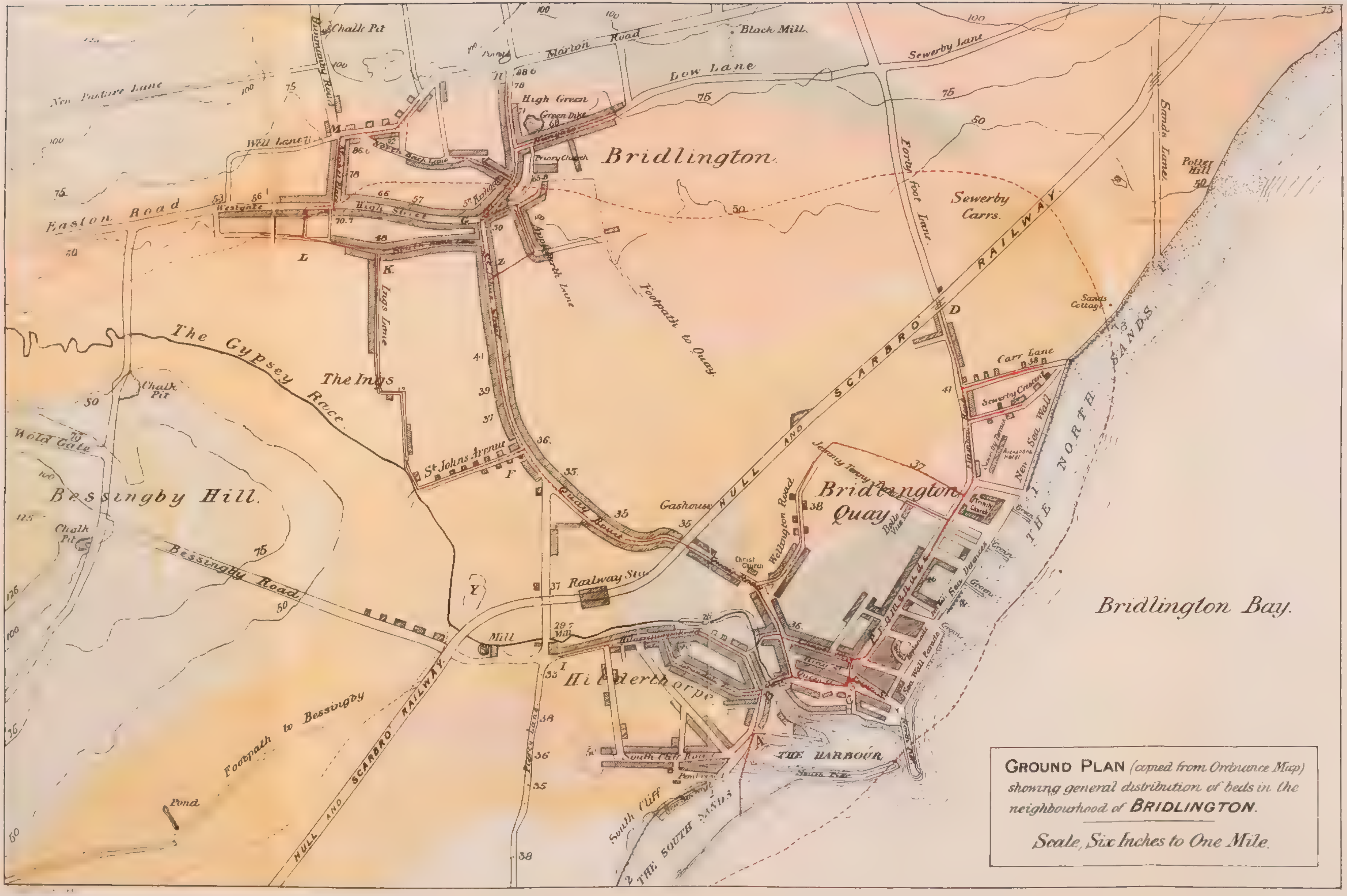
BY H. BENDELAK HEWETSON.

(Publication deferred.)

THE YOUNG STAGE OF SOME CARBONIFEROUS CEPHALOPODA

BY WM. CASH, F.G.S.

(Publication deferred.)



Ground Plan *(copied from Ordnance Map) showing general distribution of beds in the neighbourhood of* **BRIDLINGTON.**

Scale, Six Inches to One Mile.

EXPLANATION

Chalk – Green. ▬

Boulder Clay Blue.

"The Bridlington Series" – Pink

"The Gypsey Gravel" and
Fresh water Marls – Brown. ▬

The red lines show the course of the Drains of which Sections were obtained. ▬

The small numbers are levels

The Capitals refer to places indicated in the sheet of sections or in the text

The dotted lines show the supposed course of the Gypsey during the formation of the Bridlington Series – Red, and of the Gypsey Gravel – Brown

The Blue lines mark sections described and figured in former papers, as under:– ▬

1 – 1. *In Proc Yorks. Geol. & P. Soc for 1881 p. 383.*

2 – 2. *In Proc Yorks. Geol. & P. Soc. for 1882 p. 27.*

3. *(Exposure on Beach) in Geological Magazine for Sept. 1879.*

4 *(Exposure on Beach) in forthcoming Number (?) of Quart. Journ. Geol. Soc*

NOTE. *This Plan shows the general run of the beds only, omitting the minor details – this being rendered necessary by the nature of the beds which renders it impossible to obtain sharp lines on the surface.*

BIOGRAPHICAL NOTICES OF EMINENT YORKSHIRE GEOLOGISTS.

II. "ADAM SEDGWICK." BY T. M'KENNY HUGHES, M.A., WOODWARDIAN PROFESSOR OF GEOLOGY, CAMBRIDGE.

THE story of Adam Sedgwick carries us back through years full of stirring events, to times very different from our own, whether we regard the changes of the political world or the march of scientific discovery.

In a letter written when he was an old man, he says:—"On the 22nd of this month I shall have completed my 78th year, and 78 such eventful years! I well remember the breaking up of the old monarchy of France, the death of Louis XVI., the "reign of terror," the excitement which reached every nook and corner of this island, the early struggles for the abolition of the slave trade These things stand out among the remembrances of my early boyhood. Then followed the rise of Napoleon, the falling down of kingdoms, the threat of invasion, the phantom of old England's doom, and of a despotic empire which was to be built over the graves of national liberty and christian freedom. Then came the great providential change, a victory gained over a gigantic military despotism, not by the arms of man, but by the powers of nature which are the might of God's strength in the workings of His providence. And the same years, tell us in their history, of the rise of England's most anomalous and portentous display of power in the Eastern Continent. And during the same years we have seen the rise of England's children in the New World of the far West. First breaking off from the parent stock and vindicating their national freedom; then with all the energy of their race (and with all the benefits of the political freedom of Western Europe), starting on a new road towards political strength and national greatness, and advancing on it at a speed unmatched in the past history of man.

"And the triumph of sciences have gone hand in hand with these great world-wide movements; or perhaps it would be nearer the truth to say, that science has been their main spring and living strength. Gas-light, railroads, steamboats, and electric telegraph, are in my memory but things of yesterday. Years well remembered, were past in my early life before such things were so much as heard of; and yet how vastly they seem to have changed the whole outer world of civilized Christendom."

The Sedgwicks belonged to that fine old race of small landed proprietors, 'statesmen,' which is now, alas, so fast disappearing from even the Northern Dales. Among them the Sedgwicks held a prominent place, their names occurring in the register of Dent as far back as 1672.

In 1756 Sedgwick's father entered as an undergraduate at St. Catherine's College, in Cambridge: a serious business it was to get from Dent to Cambridge in those days. He took holy orders, returned to his native place and became vicar of Dent. And Sedgwick was born in the old vicarage, March 22nd, 1785.

His childhood was passed amongst the hearty, straightforward dalesmen, and he was a general favourite with them all. He delighted in every kind of sport and out-door exercises, and he had always a quick eye for anything curious and unusual, which he might come across in his scrambles amongst the crags and fells which surrounded the valley.

In later years he often refers to this part of his life as full of happy recollections. Writing from Dent, in 1860, to a friend, he says—"The home scenery is delicious, and glowing at this moment (6-30 a.m.) with the richest light of heaven; and from the door of this old home of my childhood, I can look down the valley and see, blue in the distance, the crests of the lake mountains which rear their heads near the top of Windermere. All around me is endeared by the sweet remembrances of early life, for here I spent my childhood and early boyhood, when my father and mother, three sisters, and three brothers were all living in this old home. Our home was humble, but we were a merry crew, and we were rich in health and rich in brotherly love."

Sedgwick's education was begun under his father's eye, in the old grammar school of Dent, and he afterwards went to the Sedburgh school, which had a high reputation, and was attended at that time by the sons of most of the leading statesmen, as well as by many others who have made their mark in the world.

He boarded along with three other boys, at a farmhouse kept by a Quaker. "We were treated by the family," he says "with infinite kindness, and our happy freedom made us the envy of our schoolfellows." Here he gained the habit of early rising, and he kept it all through his after life, to the very last.

In 1804 Sedgwick entered Trinity College, Cambridge, and struggled amongst men, and in the battle of the brains acheived a noble position; a splendid scholar all round, but overworked, he was advised, probably he himself suggested the prescription, to be more in the open air, and see whether nature would restore the balance. So he forsook much of his classical and mathematical work, and gave his time to the study of Geology; but he was now entangled in many varied interests, and he could not give up all the academic ties. However, into this part of his history I do not now purpose to enquire. I pass over his life at Norwich, where as Canon he resided in the old cathedral close a long part of every year. Nor will I dwell upon the part he took in college and university affairs, at one time as Vice-Master of Trinity, at another as secretary to the Prince Consort, Chancellor of the University, in times of grave interest. I go on to speak of his Geological works.

The recollection of Professor Sedgwick's personal character is still bright. His influence in moulding and guiding the opinions of his time is well known; but many would be rather at a loss to say what he did directly for geology. He wrote no great text book; he was not for ever watching, for fear any one should take an idea, or copy a sentence from him without acknowledgement; he talked freely to every one, giving them results of his original observations, he once said himself, I never had a geological secret in my life. But with all this, perhaps because of this, his papers are not so generally referred to. The *presence* of the man was so great, the personality is looked back upon as so strong, that the writings are not much appealed to in forming our estimate of him.

A short sketch of some of his published works may not therefore be wholly without profit and interest for a Yorkshire audience.

When he was appointed to fill the Woodwardian chair at

Cambridge, in 1818, he modestly said he knew nothing about geology. He had not paid special attention to the subject. His studies had been classics and mathematics, in both of which he was among the first few men of his year. But we know from many sources, that he had long been an intelligent observer of geological phœnomena. As he wandered with his gun, or fishing rod, among the crags and up the streams of his native Yorkshire, he noticed the lie of the rocks and the occurrence of fossils.

It was not long, therefore, before he attacked the most difficult questions relating to the physical structure of various parts of England. He read papers on the Lizard district, before the Cambridge Philosophical Society, in 1820 and 1821, in which, among other things, we find the Metamorphic origin of the Serpentine suggested.

He published in the Annals of Philosophy a letter dated March 17, 1822, on the Geology of the Isle of Wight, in which he confirms the views of Webster where opposed to those of Sowerby.

In speaking of the green sand and chalk formation, he points out that "when the salt in the vicinity of Cambridge is perforated for the purpose of obtaining water, the first discharge forces up a quantity of green sand, a fact which indicates the existence of the green sand formation below the salt. This sand he identifies with that seen passing under the salt in Bedfordshire; points out the mixed character of the fossils in our upper green sand, and forms the classification and nomenclature of the beds round Cambridge which is still in use.

The year 1822 is a very long time ago, and many genera and species have been re-named and re-arranged since then.

In a syllabus published in 1821, for the use of his Geological class, he gives a classification of the sedimentary rocks, which holds good on all the chief points. Of course the older Palæozoic rocks had not yet been worked out. He was, himself, the first to put them in order some ten years later. In those early days the Wernerian and Huttonian theories were still subjects for difference of opinion, and many years later, referring to the Aqueous and Igneous theories, he said playfully, that for a long time he had been troubled with water on the brain, but that light and heat had completely dissipated it. It is pleasant to read a good practical paper founded on original observation in which the character of dykes is so well discussed, as in Sedgwick's papers on the Phœnomena connected with Trap Dykes in Yorkshire and Durham. He refers them to an igneous origin, and points out that dykes are of all ages.

In describing the columnar structure it did not escape his notice that the prisms were arranged at right angles to the cooling surfaces. He mentions also the common mode of weathering into great balls by the exfoliation of successive layers from the joint faces.

He fully recognised the value of palæontological evidence. As early as 1822 we find him in a letter to the Editor of the Annals of Philosophy, stating his view of "the importance of an intimate acquaintance with certain branches of natural history. Without such knowledge," said he, "it must be impossible to ascertain the physical circumstances under which our newer strata have been deposited. To complete the zoological history of any one of these formations, many details are yet wanting."

He always carefully collected fossils and referred them to the best authorities he could find on each special group. But while he appealed to palæontological evidence, wherever he could, he recognised that the first thing was to get the rocks into the right order in the field.

In the Annals of Philosophy, for April and July, 1825, Professor Sedgwick had a paper on the Origin of Alluvial and Diluvial Formations, in which he distinguished the older formations, which we should now call drift, from the generally newer alluvial deposits. He pointed out the anomalous position and irregular distribution of the boulders, but the fact that glacial conditions once prevailed in our island and even extensive tracts all over the northern part of our hemisphere had not been recognised at that time.

At the end of the paper is an appendix, giving an account of some changes in the channels which drain the fen-land: an account full of interest to those familiar with the Humber and its tributaries and all the phænomena of silting up and warping. He concludes with this passage:—"If such extraordinary effects as those described in this note be produced by the accumulation of alluvial matter in course of a few hundred years, we may be well assured that the whole form of the neighbouring coast must have been greatly modified by the same causes acting without interruption, and without any modifications from works of art, for 3,000 or 4,000 years."

The structure of the Cumbrian Mountains and their surrounding carboniferous margin, formed the subjects of more than one able paper. But in those early days he inclined more than he would have done in later years to the opinion of Elie de Beaumont, that the mountain chains were the result of somewhat rapid upheaval, and points out the application of the theory of the parallelism of contemporaneous mountain chains to the districts he was describing. A view pushed too far by its author, but undoubtedly having a foundation on facts. He soon extended his examination of the carboniferous rocks far over the Yorkshire moorlands.

A list of his works shows how varied the range of his enquiries was, for about this time he had read papers on the Strata of the Yorkshire Coast, on the Secondary Rocks of Scotland, and of the Isle of Arran; and, in conjunction with Murchison, published many sketches of the Geology of the Eastern Alps. At one time we find him describing the raised beaches of Devon, at another, somewhat puzzled by the newer deposits along the cliffs of Sheppey.

But among all these various notes and observations, which are of a very bright order for half-a-century ago, there are some great papers which will be always standard works. First, I would name his splendid Monographs on the Magnesian Limestone and New Red Series, written between the years 1826 and 1832. There is nothing else like them belonging to that period of Geological history. He points out the enormous unconformity at the base of the series. "After the production of the rocks of the Carboniferous order, the earth's surface appears to have been acted upon by powerful disturbing forces, which, not only in the British Isles, but throughout the greater part of the European basis, produced a series of formations of very great extent and complexity of structure. These deposits (known in our country by the name of New Red Sandstone and Red Marl, and when considered on an extensive scale comprising all the formations between the coal-measures and the lias), notwithstanding their violent mechanical origin, have several characters in common, which enables us to connect them together, and, for general purposes of comparison, to regard them as one group." He points out the palæontological distinction between the Upper Limestones of the group (Muschelkalk) and the Lower (the Magnesian Limestone).

While attaching due weight to such a great unconformity for purposes of local classification he cautions us against pushing this kind of evidence too far. "We have no right," he says, "to assume, nor is there any reason to believe, that such disturbing forces either acted uniformly or simultaneously throughout the world. Formations which in one country are unconformable, may in another be parallel to each other, and so intimately connected as to appear the production of one epoch."

He gives the following classification in descending order:—

Upper Red Marl and Gypsum.
Upper Red Sandstone.
Grey thin-bedded Limestone.
Lower Red Marl and Gypsum.
Yellow Magnesian Limestone.
Marls and thin beds of Magnesian Limestone.
Lower Red Sandstone.

Some difficulty occurs in following the various accounts of the lowest beds of the group, but it can, I think, be easily explained. The Lower Magnesian Limestone passes down into red or yellow sandy beds at Pontefract. So in the Eden Valley the "brockram" or basement conglomerate of the Poikilitic series rests on red and yellow sandstones. But these are of totally different age. In the sandy beds of the roadside cliff near the great quarries just outside Pontefract, I have myself found Schizodus obscurus. These beds undoubtedly belong to the Magnesian Limestone Series.

In the Eden Valley, on the other hand, it was found by boring near Appleby that the red colour did not extend lower than a little over 100ft. into the rock. It was obviously a stain produced by infiltration from above. And there is in the Woodwardian Museum a collection of fossil plants from the N.W. margin of the same area from red beds formerly referred to the Poikilitic series which contain nothing but Upper Carboniferous species.

These facts obviously account for the difficulties which have arisen from some observers recording that the base of the Poikilitic series graduated into the Carboniferous, while others saw a strong discordancy between the two. The confusion has been increased by an attempt to force the English classification into harmony with the as yet unestablished sequence of Germany, or the still less known deposits of Russia.

"Each country, said Sedgwick, ought to be described without any accommodating hypothesis, according to the type after which it has been moulded. But in comparing the unconnected deposits of remote countries, we must act on an opposite principle; learning to suppress all local phœnomena, and to seize on those only which are co-extensive with the objects we attempt to classify."

Whatever therefore may be convenient in respect to the Dyas of Germany, or the Permian of Russia, all the attempts to bracket the magnesian limestone, and associated red marks *of England* with the carboniferous instead of making them the beginning of a new series, forming the base of the secondary rocks has been founded on stratigraphical mistakes and tends to perpetuate an unnatural classification.

Another great paper written about this time was that on "The Structure of large Mineral masses," which the council of the Geological Society thought advisable to publish before its turn, because they considered it to be introductory to other papers of his they had in hand on the origin and structure of the older stratified rocks.

Obviously it was of the greatest importance to point out the nature of concretionary action, and to distinguish indigenous segregation from the results of original mechanical accumulation. We are continually reminded of the value of accuracy of observation on such points even in the discussions of to-day. He goes on to examine another series of phœnomena of no less importance which on various occasions he had commented upon before. The obliteration of the evidence of original stratification by a superinduced structure known as cleavage, and the relation of these to joints. When deposits which were laid more or less horizontally have been in after ages exposed to great lateral pressure (whether due to the heaving up of enormous piles of rocky sediment upon compressible material in adjoining areas or to the secular shrinking of the earth's crust) they yield more or less, and so every mass or particle which has or could assume a flattened form is forced to arrange itself in planes at right angles to the pressure and we get the phœnomenon of cleavage. When shrinkage sets in or strains, causing often cracks, another set of divisional plains is formed. Others besides Sedgwick, viz.:—MacCulloch, and Bakewell, and Phillips, and especially Jonathan Otley, had observed and speculated upon these cleavage, joint, and bedding planes, but it remained for Sedgwick to work the question up, and describe their manner of occurrence and relations to one another. The results of his investigation he published in this masterly work on the structure of large mineral masses. I will not attempt to give a resumé of all his work, a mere enumeration of the seventy or eighty papers written by him would take more time than I could ask you to accord me. I ask you to bear in mind that most of what I have described was done about half a century ago, and to remember what was the state of geological enquiry then. His chief work, however, was in the old Grauwacke, and I think I would not be doing justice to my hero, or my duty to the society, which has done me the honour to allow me to give this short notice of his work, if I did not, in pointing out the progress of his enquiries into the Cambrian and Silurian rocks state briefly but clearly the circumstances which led to the great controversy between him and Murchison—a controversy which from the very personal character which it in this case, almost necessarily assumed, gave a tone to much of his later work and showed through all his later life.

In 1835 he read conjointly with Murchison before the British Association a paper on "The Silurian and Cambrian Systems, exhibiting the order in which the sedimentary strata succeed each other in England and Wales." In this paper Murchison gave Ludlow, Wenlock, Carador, Llandeilo. Sedgwick described Upper, Middle, and Lower Cambrian, and further began already to speculate on the correlation of the North Wales series with the Cumbrian of the Lake District, stating that there was not sufficient evidence to allow him to say that the lowest rocks of the lake district were on the same horizon as the lowest of Wales. He further suggested the mode of connecting Murchison's work and his own, of course he assumed that Murchison's sections were correct.

Here we find the terms Cambrian and Silurian fully recognised, and we need not refer to the mere question of nomenclature again. We have only to consider as we go on and get further evidence to what it was that each author applied his own term, and where they came in collision as to the grouping of the rocks, whose classification was true to nature.

Now what did Sedgwick mean by Cambrian previous to 1839? Following up his investigations in N. Wales he offered in 1838 a further tentative grouping which is very nearly that which must be adopted now. It is as follows in descending order :—

WALES.	LAKE DISTRICT.
Refers to Murchison's *Silurian*, as described in his papers and "forthcoming work."	*Upper Division* with no marked unconformity at the base. Flags, quartzose, greywacke, coarse slates with imperfect clevage.
III. UPPER CAMBRIAN.	
From the base of the Grits which = Caradoc of Murchison to Bala Limestone. [We shall see that Murchison's then called Caradoc was the May Hill S., not what Murchison and the Survey afterwards called Caradoc].	Lower part, Slates based on Calc Slates passing into Limestone (Coniston Limestone). [This part is a little obscure in consequence of his not having yet made out the true position of the Ireleth Slates].
II. LOWER CAMBRIAN.	
The Volcanic Series of Snowdon, Glide Fawr., &c.	Slates, compact felspar, felspar porphyry, and brecciated porphyries.
I. [He does not yet give a name to these.]	
The older Slates and Quartzites of Anglesea and Carnarvonshire.	Nothing to show that this group is analogous to that of Skiddaw.

He quotes Murchison's Llandeilo Flagstones and Caradoc.

He did not add much to the above in his paper read before the Geological Society, in 1841, but now the "Silurian system" had been published, and the difficulty of making his work agree with Murchison's sections was evidently increasing.

In June, 1843, he offered some further notes on N. Wales, and still finding no organic remains in the oldest and generally most highly metamorphosed rocks, did not very clearly define their age, but placed them correctly at the base of the whole series. He now seemed to avoid questions of nomenclature, but we have no difficulty in making out what the rocks were that he referred to under the head of Middle Division of the Cambrian Slates, as he gives a good list of fossils which shows them to be the well-known Bala Beds of our modern terminology. In November of the same year, he wrote a fuller paper on the Palæozoic (Protozoic) Rocks of N. Wales, in which he gives some further sub-divisions, and fuller descriptions of sections across the country.

There is some difficulty in following the palæontological evidence in the absence of figures, as more knowledge has called for closer discrimination in the species and genera, and many names have been changed since those days, as may be seen by reference, for instance, to the Silurian system, where the excellent figures enable one to determine at once what species was intended. Therefore, it is probable that when, for example, we read of Asaphus (Ogygia) Buchii being found about the horizon of the Arenig rocks, it was probably Ogygia scutatrix or peltata, and so on for many others. However, we have here a clear sequence given in the Cambriam Rocks. The Arenig slaty beds overlaid by the porphyritic series, and this by various divisions clearly belonging to the Bala Beds.

We see clearly enough what he meant by Cambrian, viz., every rock that could be made out to follow in conformable succession below the Sandstones at the base of the Denbigh Flags. He left somewhat doubtful many of the metamorphic rocks of Anglesea and Carnarvonshire. He had not yet clearly correlated the rocks of N. Wales with those of the Lake District, and he felt that as he proceeded south there was much difficulty in making his sections agree with those of Murchison, but his series was clear, as shown in the vertical section.

In the latter part of this paper (will it be believed?) the nomenclature used by Sedgwick was altered in the proof-sheets by Warburton, in order to bring it into accord with the now more favoured terminology of Murchison. Altered without Sedgwick's consent. This statement has been made over and over again and never contradicted.

In 1843 he filled in some details but made no change in the order of succession. The following series shows what he included in his Bala beds.

a. Slates W. of Areing, with a large trilobite, like Asaphus (Ogygia) Buchii? O. peltata.

b. Slates with interbedded volcanic ejectamenta.

c. Dark earthy slates, with Trinucleus Caractai (= T. concentricus), Asaphus Powisii, Leptæna sericea, encrinites, &c.

d′d″. Shales with subordinate Limestone, *d′*, from which he gives very full lists of fossils.

Then follow other shales, *d‴*, and above them the Hirnant Limestone, *e*, the true relations of which I hope to describe elsewhere.

Many of Sedgwick's old sections, which he exhibited when these papers were read are still in existence, and represent what is found recorded in the published papers. They can be compared with the Survey sections. It will be seen that the Survey has drawn no lines not pointed out by Sedgwick, and when it has indicated by letter the occurrence of formations not mapped, it will be seen that Sedgwick had suggested their separate existence long before.

Take the section from Trawsfynydd to Cynicht. It was made in 1846 from Sedgwick's much earlier notes. His papers of 1838 give the sequence, and from a comparison of this with the Survey section (28, C and D), it will be seen that they adopted all his classifications. This section is taken across the typical district from which later he named the whole of the Lingula flags, the Ffestiniog group.

In other sections described in his papers, he gives the Lingula beds, the Pisolitic iron-ore beds, *i.e.* Arenig and the overlying slates, all of which are mentioned in the text under the head of Cambrian.

The section from Pentrevoclas to Abergele shows the grits which Sedgwick took as the base of the Silurian, below which he supposed the unconformity to occur, which he mentioned in his paper before the Geological Society, above quoted.

The Survey did not set aside but confirmed Sedgwick's classification over all N. Wales. Where was the difficulty? Why, in trying to make these sections fit on to Murchison's, which were utterly wrong.

Let us now consider what Murchison's grouping was, and on what founded. We will go to Llandeilo to see what he meant by Llandeilo rocks. The beds to the west of Llandeilo were changed from Cambrian to Caradoc. The Cambrian and Llandeilo had to be turned the other way up. The Caradoc on the east of the valley was changed to Llandovery.

This, however, was not so serious when we consider what was then meant by Caradoc which is quite clear from the description of it in the Silurian system and the fossils said to characterise it. See Sil. Syst., pls. 19, 20, 21, from which it will be seen that it included part of the Upper and part of the Lower Silurian. Thirteen years later, Sedgwick cleared this up in his paper on a proposed separation of the so-called Caradoc Sandstone into two distinct groups, 1, May Hill Sandstone, and 2, Caradoc Sandstone. So Murchison had not got Llandeilo or Caradoc right in his typical sections.

It would not be profitable to try to pick holes in such a fine production as the Silurian system, where the labours of Lewis, of Agmestry, and of Williams, of Llandovery, and of the author are so skilfully worked in, and the beautiful illustrations of which make it a classic work never to be set aside as useless.

But a question has to be answered in common justice.

Two prominent geologists had put forward two different and contradictory schemes, before 1839. Which of the two was right in 1839? I submit without hesitation that Sedgwick was right in 1839, and go further, I say that Sedgwick's is still the classification most true to nature.

If you look at Murchison's later works, or at the publications of the Survey, which were issued under his direction, you will find that the great stratigraphical errors mentioned above have been corrected. But how? Was it by acknowledging that he had misunderstood a local anticlinal bringing up some of Sedgwick's Lower Bala, and had drawn a continuous ascending section across it; that he had missed the true break at the base of the Silurian, and grouped a great piece of the upper series with the lower unconformable beds? Alas! that was not done, he swept into his Silurian, all Sedgwick's Cambrian, down to the base of the Bala beds, and finding no break there, from time to time took in more of it till he left him at last only the lowest group, the Harlech, Llanberis, and Bangor beds.

Well, what next? Will it be believed that he now tried to throw the blame of his mistakes on Sedgwick; said, moreover, that it was his friends of the Survey, who applied the term Silurian to the slaty rocks of the western part of Wales?

It was no small injustice that wrung from the unselfish, noble Sedgwick such reproachful words, and that sent him to his grave with a sense of unrighted wrongs, of faithless friends and ungenerous enemies.

Is it good for the world that generosity and unselfishness shall be for ever unrecognised? Is it good for the student of science to feel that self-assertion is the chief requisite for success? The better nature of man rebels against such things. Many a one whose nature inclines him to share his last loaf with his hungry brother-man, may find the streams of charity dry within him, as he learns that he has been again and again cheated, and that when the world learned it was so, it coldly turned away.

But I would not end with this sad story.

Sedgwick's was a nature charged to the full with human sympathy. Bring joy near him, and he rejoiced; bring sorrow before him, and his pity overflowed in consolation; out of the fulness of his heart, his mouth spoke unmeasured unpremeditated words of gladness, or of sympathy. And though the friends of his youth passed away as shadows, he ever gathered round him the young and happy, and caught some of their life. Full of interest in all that was going on around him, the brave old man died in harness; and in 1873 was buried with the great men among whose memories he had so long lived. A simple A.S. marks the spot where his body was laid in the chapel of Trinity College, Cambridge.

GEOLOGICAL EXCURSION TO HOLDERNESS, THE KILNSEA SHELL MOUNDS, SPURN POINT, AND THE PILE DWELLINGS AT ULROME. BY JAMES W. DAVIS.

AN excursion of the members of the society was made on July 21st to 23rd to Patrington, Easington, Kilnsea, and Spurn Point, and to Hornsea, Skipsea, and Ulrome, all in the district of Holderness. The party, on arriving at Patrington, were conveyed in carriages to the Neptune Inn, at Easington, where Mr. Lawton, the landlord, had tea in readiness. This part of the proceedings being completed, the carriages were re-entered, and the party drove to Kilnsea, a small village at the commencment of the narrow ridge of sand constituting Spurn Point. Two examples of the old refuse heaps or kitchen middens were visited, the first on the coast washed by the German Ocean, the second about 200 yards up the Humber, beyond the point where the road reaches the village. The early inhabitants appear to have selected or constructed a hollow in the glacial clays, about nine or ten feet broad, perhaps 60ft. in length, and four or five feet deep in the centre, with sloping sides. In this hollow they deposited the refuse from cooking, and other matters. The situation of the midden is usually indicated by a layer of oyster shells. The loamy soil above these is soft and comparatively loose, frequently a dark brownish black colour. It contains broken bones of the cow and sheep; and to a less extent of some other animals, of birds, &c., which served for food. Broken pottery of a coarse material and only partially burnt, thin Roman-like bricks and pieces of glass, and more rarely flint, bone, iron, and bronze implements are discovered. The whole is covered by a greater or less thickness of soil.

It unfortunately happened that the tide was at its highest point when the party first reached the middens. Considerable collections were however made, a bronze buckle and an iron instrument being the principal finds in addition to bones and pottery.

The amount of denudation on this part of the coast is very great, though not always proceeding at the same rate. The average is probably 12ft. to 14ft. per annum; but during a severe storm in March last, as much as 50ft. in breadth was removed along a considerable line of coast. In other places, on the contrary, the foreshore becomes rapidly extended, as for instance at Patrington, where what is termed the Sunk Island, comprising 7,000 to 10,000 acres, has been reclaimed from the Humber, and is now cultivated; and whereas Patrington was formerly a seaport town, it is now far inland. Kilnsea church was washed away about sixty or seventy years ago, and its position is now 240 yards from the shore. Huge blocks of masonry, concreted together, rise considerably above the sands on the old site of the church. From Kilnsea towards Spurn Point the land rapidly converges southwards, and in about a mile has become so narrow between the North Sea on the one hand, and the Humber on the other, that any one might shoot an arrow across. The blown sand is piled up seawards to a height of about 12ft., but in the opposite direction it thins out to the level of the water. Further on the sandy cliffs become considerably higher, but proportionately narrow; they form in section a cone-shaped mound perhaps 20 yards wide, five or six yards across the top, and rise from the level of the sands to a height of 20 to 25ft. These sand dunes form a very fragile barrier to the stormy waters of the German Ocean, and the Board of Trade are at present engaged in supporting the bank seawards, by driving into the sand or glacial clay a long series of wood piles and groins. The necessity for this is proved by the fact that a short distance nearer the point, the sea broke through the barrier, and for some time resisted all efforts to stop it. Eventually, a wall was built of chalk brought from Hessle, and the continuity of the land was made and has since been maintained. At the extremity of the point its area widens considerably, and a short distance from the end is placed the lighthouse. Near the structure at present used, is a second one, which is now approached by a bridge, and is quite separated from the land at high water. The weather, showery during the early part of the day, cleared up, and a good view of the long line of the Lincolnshire coast was visible Numerous vessels constantly entering and leaving the Humber made a very pretty sight. The sandy soil of the headland affords nourishment to several species of plants and long grass. The latter was interspersed with lovely patches of pink and yellow flowers; rare and beautiful butterflies hovered about; and the tern or sea swallow gliding, fish in mouth, towards its offspring nestled in the sand, presented an extremely interesting picture.

On Monday morning the party proceeded to Hornsea, a summer resort for the people of Hull. It is situated on the coast, and the country in its neighbourhood is constituted of the stiff glacial clays and gravels characteristic of the whole of Holderness from the chalk of Bridlington to the Humber. The country is slightly undulating; little rounded hills of gravel rising from an otherwise unbroken level of small valleys. The lower parts of the country were, until comparatively recent times, covered by inland lakes, connected with one another, and ramifying in every direction. The construction of large drains and the general drainage of the surface has run off the water, and where was formerly a series of lakes and bogs, there is now a rich soil producing abundant harvests. An example of the old fresh-water lake still remains in Hornsea Mere, about half-a-mile from the shore, and from the point of view indicated it is peculiarly interesting. It is about a mile in length, and its deeper parts are below the level of the sea. Having inspected the lake, the members were driven to Skipsea, a distance of five miles, where they were met by Mr. Thomas Boynton, of Ulrome Grange, and the guidance of the party for the remainder of the day was relegated to his hands.

Proceeding to the shore at Whithowe, Mr. Boynton pointed out the site of one of the ancient lakes already mentioned. It originally extended far out to sea, and was of such extent and importance that Edward I., the lord of the manor, granted a tithe of fish to Robert de Chester in 1288. At present it is exposed in the cliff section, occupying a hollow in the surrounding glacial till or clay. Its principal characteristic consists in the thick beds of peat, which occupy and fill up the hollow. The peat has been formed by the gradual accumulation of vegetable matter at the bottom of the lake, and in some instances is nearly pure carbonaceous matter, proving that the influx of water bearing earthly matter in suspension was a circumstance of comparatively rare occurrence. Proceeding from the coast past the church, which possesses a beautiful little porch erected in the reign of Queen Anne, the stronghold at Skipsea Howe was visited. These are very extensive and perfect, and, without doubt, afforded means of defence and protection to its inhabitants and those of the surrounding district. An interesting description of the site and its historical associations was given by the director; but as the members were more concerned in geological than archæological research, we pass them over, merely remarking that the original earthworks seem to have been erected by the ancient Britons far back in remote antiquity, and that their works have been greatly enlarged and strengthened by succeeding tribes or peoples.

Mr. Boynton next conducted the members along the side of the Skipsea and Barmston Drain to Ulrome, where the Rev. E. M. Cole, the author of a popular treatise on the geology of the East Riding, recently issued, and others from the neighbourhood of Driffield and Malton, joined the party. It is at Ulrome that the pile dwelling, discovered and excavated by Mr. Boynton, is situated. Whilst deepening the drain three years ago, a number of bone tools and rotten timbers were discovered, which had evidently been worked and used by some former inhabitants of the country. They were, in some instances, sharpened at one end in a rough and rude manner, and appeared to have been used as piles. Mr. Boynton's curiosity was excited, and he commenced an excavation on the east bank of the drain in the first instance, and afterwards on the opposite side, A rectangular surface is now exposed about 20 yards by 30, and the whole of this is covered by trunks of trees laid horizontally, and fastened and held in position by pointed piles driven into the ground on each side or at the ends. The general construction, as explained by Mr. Boynton, is as follows:—The structure was erected on the edge of a lake, with rising ground eastwards and westwards. The bed of the lake was composed of sandy gravel, above which about 2ft. of peat had been deposited. On this the builders placed the tree trunks, crossing each other horizontally, and for the most part without any definite arrangement. The largest trunks measure about 18in. in diameter and perhaps 20ft. in length, except in rare instances they have not been hewn into shape, but laid in the bed of the lake in the condition in which they were felled after the branches had been removed. The largest trunks are placed from east to west across the course of the stream, which connected more expanded and lake-like areas to the northwards and southwards. Transversely with the timbers from east to west, others were laid and fastened in position so as to form a tolerably compact and solid framework. They were fastened in position by rudely pointed stakes driven, generally, with a diagonal inclination, into the bottom of the lake. At the north-east corner of the platform thus formed, a pair of parallel timbers of large size, about 5ft. apart, and more carefully hewn and fixed than most of the others, appear to indicate that the entrance, or connection between the dwelling and the adjoining land, was placed in this position. The trunks and branches consist for the most part of oak, ash, birch, hazel, and willow. Hazel-nuts are frequently met with.

The interstices between the timbers of the platform were filled with broken wood and twigs until a level surface was obtained. On the solid surface thus obtained, there was placed an additional thickness of about 18in. of broken twigs and bark, and on this foundation, probably reaching a short height above the surface of the water, were erected the dwellings of the builders. Since the demolition of the buildings or dwellings there has accumulated about 3ft. of peat and peaty marl, and above this, forming the surface, there is more than a foot of warp and soil; so that the whole is about 10ft. in depth from the surface of the ground to the bed of gravel at the base. It is probable that after the first platform had served for the support of dwelling erected upon it, that it became necessary to raise it; for it is found that a second one has been placed above it. The stakes used in fastening the timbers of the second, are frequently found driven into the timbers of the preceding one, so that the older structure must have been laid a considerable time, and the timbers have become more or less decayed, or this could not have happened. The stakes of the latter dwelling have a longer and better made point than the older ones, and appear to have been cut by superior tools.

During the excavation many interesting relics of the occupiers of the dwellings have been found, mostly consisting of stone and bone implements. Amongst the former are several rounded stones, used for pounding grain or other matters; pointed or sharpened stones pierced in the middle for the introduction of a handle, and used as hammers; a large stone of oval form, coarse texture, with flat surface, exceeding a foot in diameter may have been used in grinding food. Flint flakes used as knives and for other purposes have been found. The bone implements are mostly of large size and rude form. The large leg bones of the cow (Bos longifrons), probably the humerus, broken off diagonally about 8in. from the joint, and a hole bored immediately below the joint, for the insertion of a stick, formed an implement that would serve very well the purpose of a hoe for breaking up the land. The antlers of the red deer appear to have been used by these people as in other similar places, for digging purposes, and are frequently met with. Numerous nuts are found; pieces of pottery, of an early British type occur. In addition to the bones of the animals named, there have been found the jaws of wolves, tusks of wild boar, head of horse and of red deer; bones of sheep, dog, and of smaller animals, as well as the bones of birds. All these have been found beneath the upper structure, amongst the twigs and bark in the interstices between the timbers of the lower and earlier one, at a depth about 6ft. from the surface, and about 4ft. above the bottom of the lake.

In the upper part of the dwelling a fine bronze spear head was found. The discovery of this implement has led to the inference that the later dwelling was erected during the period usually denominated the Bronze Age; whilst in all probability the older foundations were laid at a much earlier time represented by the early Stone Age. It will be interesting to note the discoveries during future excavations, to ascertain whether other dwellings exhibit a similar duplicate arrangement, and afford evidence that peoples of so different intelligence and civilization, as those living in the Neolithic and Bronze Ages, occupied dwellings so nearly approximating in structure, as appears to have been the case in the present instance.

Judging from the remains which have hitherto been discovered, it appears probable that the people who erected the dwellings on the borders of the lake did so for protection against the wild animals which existed in the country at that time and for long afterwards, rather than for defence against human foes. That they followed agricultural pursuits is proved by the bone implements, which are admirably adapted for working in the light warpy soil on the higher ground bordering the lake. Mr. Boynton suggests that the lake dwellers, if alarmed, could easily retire to Skipsea, which was probably an intrenched and fortified place at the time the dwellings were erected, and that, under ordinary circumstances, they were peaceable and industrious agriculturists.

Having carefully examined the site and structure, so far as it remains, of the old dwelling, those present were conducted by Mr. Boynton to his residence, Ulrome Grange, where he entertained the company to dinner. At its conclusion the Hon. Secretary expressed the indebtedness of the society to their host, and also stated that the thanks of the scientific world were due to Mr. Boynton for the energy and skill he had displayed, and the expense he had incurred in excavating so large an area of the old pile dwellings. This was the first recorded instance of a similar structure having been found in England. Dwellings of a similar character have been found and investigated in Scotland and Ireland with great scientific advantage, and he (Mr. Davis) hoped, and had no doubt, that Mr. Boynton would be amply repaid for the trouble he had taken, by the extension of the knowledge of the people and their habits, whose otherwise unrecorded history he was so ably assisting to elucidate. Mr. Boynton replied that the visit of the society had afforded him considerable pleasure, and he wished to state his opinion that the dwelling which had been examined was not an isolated instance, but that in all probability the country was studded with them. He already knew the sites of five such dwellings, or clusters of dwellings, for he did not think that they were inhabited by single families only. Each of those would no doubt well repay examination, so that the knowledge of them might yet be very much extended.

After an examination of Mr. Boynton's rich collection of objects obtained from the excavations, the party left to return to their several destinations, having spent an extremely pleasant and instructive holiday in Holderness.

SECRETARY'S REPORT.

THE present meeting is the fourth held during the year. The members have met on three occasions at which papers have been communicated; the fourth took the form of an excursion in Holderness. The first meeting was held at Leeds, in the Lecture Theatre of the Philosophical and Literary Society, on February 14th; Wm. Cheetham, Esq., presided, and papers were contributed by Messrs. G. R. Vine, W. H. Hudleston, President of the Geologists Association, London; and Arnold Lupton, Memb. I.C.E., Mining Instructor at the Yorkshire College. The second meeting was held at the Town Hall, Ripon, on May 9th, and the chair was occupied by Rev. W. C. Lukis, M.A., F.S.A., who gave an address; papers were contributed by Mr. H. B. Hewetson, and Rev. J. Stanley Tute, B.A.

On July 21st and 23rd, an excursion to Patrington, Kilnsea, and Spurn Point took place. The members met at Hull, and went by rail to Patrington, after inspecting the beautiful old church, they were driven to Easington, and thence to Kilnsea: at the latter place a number of ancient "Kitchen middens" were examined. On the following day some of the party walked to the end of Spurn Point. The members left Easington on the 23rd, and proceeding by way of Hull, went to Hornsea, and after inspecting Hornsea Mere, a large lake below the level of the sea, drove to Skipsea, where Thos. Boynton, Esq., of Ulrome Grange, met the party. Proceeding first to the coast, a section of an ancient lake exposed in the cliff, was inspected. From thence, by way of Skipsea Howe, the party walked along the side of the Barmston drain to a lake-dwelling at Ulrome, which Mr. Boynton discovered, and has since excavated.

Full and detailed particulars of the excursion, and more especially the Lake Dwelling, will be found in a separate paper to be printed in the proceedings of the society. After inspecting the Lake Dwelling, the members were conducted by Mr. Boynton to his residence, where he entertained them at dinner, and afterwards exhibited his collection of implements and pottery found during the excavations of the dwellings, as well as a magnificent series of flint weapons found on the surface of the surrounding country.

The annual meeting was held at Halifax, in the Lecture Theatre of the Literary and Philosophical Society, on November 28th. The President of the Institution, Lieut.-Col. Louis J. Crossley, J.P., F.R.M.S., &c., occupied the chair, and afterwards entertained the members present at dinner. Papers were read by Prof. T. Mc. K. Hughes, M.A., &c., Professor of Geology, at Cambridge; Messrs. Richard Carter, C.E., W. Cash, F.G.S., Geo. R. Vine, W. V. Veitch, M.D., Geo. W. Lamplugh, and T. H. Easterfield.

The thanks of the society are due to the councils of the Leeds and Halifax Philosophical Societies, and to the City Council at Ripon, for the use of their rooms; to the gentlemen who have presided at the meetings; and to Mr. Boynton, for the generous help and guidance, readily accorded during the visit of the society to Holderness.

The present number of members is 212, of whom 25 have compounded for their annual subscription by a payment of six guineas, and 187 are ordinary members; 17 new members have been added during the year. The death of R. W. Morrel, of Bradford, has deprived the society of a useful member, and in addition, seven others have withdrawn from the society, leaving a nett gain of nine members during the year.

The thanks of the society are due to the Local Secretaries for their continued interest in the society, and for the painstaking manner in which they have on all occasions attended to the duties of their office. The following is a list of the Local Secretaries and the towns or districts under their supervision :—

Barnsley	Thomas Lister.
Bradford	Thos. Tate, F.G.S.
Bridlington	Geo. W. Lamplugh.
Brighouse	T. W. Helliwell.
Driffield and District	Rev. E. Maule Cole, M.A., F.G.S., &c.
Halifax...	George Patchett, junr.
Huddersfield	Peace Sykes.
Hull	G. J. Wilson, M.A., &c.
Leeds	J. E. Bedford.

Mexbro'	Rowland Gascoigne, F.G.S.
Middlesbrough	W. Y. Veitch, M.D.
Selby	J. T. Atkinson, F.G.S.
Sowerby Bridge	J. Marshall, F.G S.
Thirsk	W. Gregson.
Wensleydale	W. Horne.

The following is a list of those societies to which the proceedings of this society are forwarded, and which in return present us theirs :—

Essex Naturalists Field Club.
Norwich Geological Society.
Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociètè-Geologique du Nord.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Royal Physical Society of Edinburgh.
Oversigt over det Kongelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Herefordshire Field Club.

Copies of the Proceedings of the Society for the following years may be had on application to the Honorary Secretary, Chevinedge, Halifax, price 2s. 6d. each :—

1840, 1841, 1842, 1843, 1844-5, 1845-6, 1847, 1848, 1851, 1853, 1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6, 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882.

During the past year the quarrying operation in the immediate vicinity of the Rayhill Fissure have been of such a nature as to prevent the progress of the work of the Committee appointed to superintend its exploration. There is every probability that, with the approach of next spring, the whole of the intervening limestone will have been cleared away, and that active operations may be again commenced in the Fissure.

The society acknowledges, with much pleasure, its indebtedness to Mr. W. H. Dalton, of H. M. Geological Survey, for his kindly rendered assistance in the compilation of the Bibliographical lists of works published during the past year, and which are appended.

Statement of Receipts and Expenditure of the West-Riding Geological and Polytechnic Society,

From OCTOBER, 1882 to OCTOBER, 1883.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	10	0	0	By Cash paid into the Bank	62	9	9
,, Subscriptions	62	9	9	,, Cost of Photographs and Stationery ...	68	0	10
,, Beckett & Co.	68	0	10	,, Balance in hand	10	0	0
	£140	10	7		£140	10	7

THE TREASURER IN ACCOUNT WITH MESSRS. BECKETT & CO.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	38	11	9	By Cash from Bank	68	0	10
,, Cash paid to Bank	62	9	9	,, Balance at Bank	33	15	9
,, Interest	0	15	1				
	£101	16	7		£101	16	7

CAPITAL ACCOUNT.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	148	18	0	By Balance at Bank	165	2	8
,, Subscriptions	12	12	0				
,, Interest	3	12	8				
	£165	2	8		£165	2	8

RAYGILL QUARRY EXPLORATION FUND ACCOUNT.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	29	4	0	By Balance at Bank	29	16	1
,, Interest	0	12	1				
	£29	16	1		£29	16	1

Examined and found correct, G. PATCHETT, Junr.

MINUTES.

Meeting of the Council, Dec. 13th, 1882, at the Museum, Leeds. Present, R. Carter, Esq., in the chair, Messrs. Cheetham, Bedford, Tate, Sladen, Atkinson, Rowley, and Hon. Secretary.

The Minutes of last meeting were read and confirmed.

Proposed by Mr. Atkinson, seconded by Mr. Cheetham, "That the following amounts be paid."

E. Wormald	£1	12	0
"Pontefract Express"	0	7	6

Proposed by Mr. Sladen, seconded by Mr. Tate, and carried, "That the recommendation of the revision Committee that a series of Biographical Memoirs of eminent Yorkshire Geologists be printed in the proceedings, be adopted; and that the Memoir of John Phillips, by Mr. J. W. Davis be accepted for this year's proceedings."

Proposed by Mr. Cheetham, seconded by Mr. Tate, and carried, "That the next Meeting of the society be held at Leeds, in February, and that Messrs. Vine and Hudleston, and others, if available, read papers.

GENERAL MEETING held in the Lecture Theatre, Museum, Leeds, Feby. 14th, 1883, Wm. Cheetham, Esq. occupied the chair.

The Minutes of last General Meeting were read and confirmed.

Proposed by Mr. McLandesborough, seconded by Mr. Davis, and carried, "That Mr. A. E. Preston, C.E., F.G.S., The Exchange, Bradford, be a member of the Society."

Papers were read by W. H. Hudleston, F.G.S., &c., "On the Physical Geology and Geography of Palestine and the adjacent countries."

Arnold Lupton, C.E., F.G.S., "On the Channel Tunnel; notes of a visit."

George R. Vine, "Notes on the Carboniferous Polyzoa of West Yorkshire and Derbyshire (an attempt to identify Professor Phillips' species)."

Proposed by Mr. Davis, seconded by Mr. Rowley, "That the next Meeting of the society be held at Ripon," carried.

Proposed by Mr. Tate, seconded by Mr. Lee, and carried, "That the thanks of the meeting be given to the Chairman and authors of papers."

Meeting of the Council, Town Hall, Ripon, May 9th, 1883. Present, Rev. W. C. Lukis, F.S.A. in the chair, Messrs. Gregson, Cole, and Davis.

The Minutes of the last meeting were read and confirmed.

The following accounts were passed and ordered to be paid.

	£	s.	d.
A. Megson & Sons -	53	15	6
E. Wormald - -	1	14	0
Hy. Sykes - -	1	1	0
Autotype Co. - -	11	10	4
"Pontefract Express"	0	7	6
,, Telegraph	0	7	9
,, Advertiser	0	8	0

It was resolved that there be an excursion of the members on the Yorkshire Coast, the district between Scarbro' and Filey being suggested if suitable arrangements can be made, in the early part of August. Resolved that the photograph for next year be a section on the coast, near Scarborough.

GENERAL MEETING at the Town Hall, Ripon, on May 9th, 1883. The Rev. W. C. Lukis, M.A., F.S.A., Rector of Wath, occupied the chair. The Minutes of last General Meeting were read and confirmed.

The following gentlemen were elected members of the Society :—
Sir Charles Dodsworth, Bart., Thornton Watlass, Bedale.
Jas. Carter, Burton House, Thirsk.
T. Carter Mitchell, Topcliffe, Thirsk.
J. Dyson Butler, Estate Buildings, Huddersfield.
Jno. Hanstock, Denby Grange, near Wakefield.
Mrs. Tetley, Foxhills, Weetwood, Leeds.
Thos. Dalton, Albion Street, Leeds.
Percy Lund, Ilkley.
Robt. Peach, Harrogate.
Wilfrid H. Hudleston, M.A., F.G.S., Culverden Lodge, Oatlands Park, Weybridge.

The Chairman stated that the next meeting of the society would be held as an excursion on the Yorkshire coast, in August, and the annual meeting at Halifax.

The Chairman gave an address.

The following papers were read :—
H. B. Hewetson, "On the shell mounds or kitchen middens at Spurn Point"
Rev. J. Stanley Tute, B.A., "On the sequence of the Permian Rocks, near Ripon.
Rev. J. S. Tute, B.A., "On a raised beach at Redcar."

T. C. Mitchell read a communication "On a peculiar celt or flint which had been obtained from a French millstone."

Proposed by the Rev. E. M. Cole, seconded by Mr. Cheetham, that thanks be given to the Chairman, and authors of papers.

Meeting of the Council,—At the Museum, Halifax, Nov. 28th, 1883. Present, Wm. Alexander, M.D., J.P., in the chair; Messrs. Cheetham, Rowley, Cash, Sykes, Crossley.

The Minutes were read and confirmed.

Proposed by Mr. Cheetham, seconded by Mr. Sykes, that the following accounts be paid.

	£	*s.*	*d.*
E. Wormald - - -	0	7	3
S. S. Hill - - -	0	4	0
G. Willis - - -	2	6	0

Annual General Meeting in the Lecture Theatre, Literary and Philosophical, Halifax, Nov. 28th, 1883.

The chair was occupied by Lieut.-Col. Louis J. Crossley, J.P., F.R.M.S., &c.

The Minutes of the last general meeting were read and confirmed.

The Honorary Secretary read an annual report and balance sheet, which was adopted on the motion of the Chairman, seconded by Mr. Rowley.

The following gentlemen were elected members of the society:—

H. B. Hewetson, 11, Hanover Place, Leeds.
T. C. Heslington, North Road, Ripon.
— Scargill, East Parade, Sheffield.
Ed. Hailstone, F.S.A., Walton Hall, Wakefield.
R. T. G. Abbott, Auburn Hill, Malton.
Joseph Davidson, F.C.S., Holywell Green, Halifax.
T. C. Scratcherd, Halifax.
Francis Fleming, Halifax.
George Patchett, jun., Halifax.
W. Gaukroger, Halifax.
L. J. Crossley, J.P., &c., Moorside, Halifax.
Geo. R. Vine, 112, Hill Top, Attercliffe, Sheffield.

A letter was read from John Brigg, Esq., tendering his resignation of the office of Treasurer.

It was proposed by Mr. Cheetham, seconded by Mr. Parke, and carried, "That the thanks of the society be given to Jno. Brigg, Esq., J.P., for his valuable services as Treasurer during the past eight years; and to the officers for their services during the past year."

Proposed by Dr. Alexander, seconded by Mr. Rowley, and carried, "That the Marquis of Ripon be re-elected President for the ensuing year."

Proposed by Mr. Rowley, seconded by Mr. Bedford, and carried, "That the following noblemen aud gentlemen be elected Vice-presidents for the next year:—Earl Fitzwilliam, Duke of Leeds, Earl of Effingham, Earl of Dartmouth, Earl of Wharncliffe, Viscount Galway, Lord Houghton, Viscount Halifax, H. C. Sorby, Esq., LL.D., T. W. Tew, Esq., J.P., Walter Morrison, Esq., J.P., W. T. W. S. Stanhope, Esq., J.P., Lieut.-Col. L. J. Crossley, J.P., and Thos. Shaw, M.P., &c.

Proposed by Mr. Davis, seconded by Mr. Stott, and carried, "That W. Cash, Esq., F.G.S., &c., be elected Treasurer."

Proposed by Mr. Crossley, seconded by Mr. Gaukroger, and carried, "That Jas. W. Davis be the Honorary Secretary for the ensuing year."

Proposed by Mr. Peach, seconded by Mr Gray, and carried, "That the following gentlemen form the council for the ensuing year:—

Wm. Alexander, M.D.	R. Carter, C.E., &c.
W. Cheetham.	J. R. Eddy, F.G.S.
T. W. Embleton, C.E.	E. Filliter, C.E.
Prof. A. H. Green, M.A.	Prof. L. C. Miall.
R. Reynolds, F.C.S.	W. Rowley, F.G.S.
W. S. Ward, Esq., F.C.S.	G. H. Parke, F.G.S.

The Chairman gave a brief address, and the following Papers were read:—

Professor Thos. M'Kenny Hughes, M.A., &c., "Biographical Sketch of Prof. Adam Sedgwick."

Richard Carter, Esq., C.E., F.G.S., on "A Meteorite which fell at Harrogate, in June, 1883."

Wm. Cash, Esq., F.G.S., on "The young stage of some Carboniferous Cephalopoda."

Geo. R. Vine, Esq., on "The Entomostracoda of the Richmond and North Yorkshire Carboniferous Shales."

W. Y. Veitch, Esq., M.D., on "The evidences of raised Beaches on the Yorkshire Coast."

Geo. W. Lamplugh, Esq., on "The Drainage Sections at Bridlington.—The Fresh-Water Gravels."

T. H. Easterfield, Esq., on "A Glacial Deposit near Doncaster.'

Mr. Cheetham proposed, and Mr. Parke, Seconded, a vote of thanks to the Chairman, and authors of Papers, carried.

The members of the society, at the invitation of Mr. Crossley, adjourned to the Masonic Hall, where he entertained them at dinner.

SUMMARY OF GEOLOGICAL LITERATURE RELATING TO YORKSHIRE, PUBLISHED DURING 1883, WITH ADDENDA FOR 1879-1882.

Compiled by JAMES W. DAVIS.

1879.—ADDENDA.

CAMERON, A. G. Lecture on Geology. *Cleveland News*, Feb. 15.

CLARK, J. E. Askham Bog. *Nat. Hist. Journ.*, vol. iii., pp. 113-115, pl. viii.

CROSSKEY, Rev. H. W. Seventh Report of the Committee for recording Erratic Blocks. *Rep. Brit. Assoc.* for 1879, pp. 135-140.

DAKYNS, J. R. Lenticular Hills of Glacial Drift. *Geol. Mag.* dec. ii., vol. vi., pp. 382-383.

——— The Purple Boulder Clay at Holderness. *Ibid*, p. 528.

DE RANCE, C. E. Fourth Report of the Committee . . . . on the Underground Waters . . . . of England. *Rep. Brit. Assoc.* for 1878, pp. 382-419. (Yorkshire, pp. 412-416.)

——— Notes on some Triassic Borings. *Trans. Manch. Geol. Soc.*, vol. xv., pt. v., pp. 90-112. (Middlesboro'.)

ETHERIDGE, R., junr. Notes on the Bivalves contained in the Gilbertson Collection, British Museum and figured in Phillips' "Geology of Yorkshire." *Geol. Mag.*, dec. ii., vol. vi., pp. 161-166.

GUNN, W. Glaciation of the West Yorkshire Dales. *Geol. Mag.*, dec. ii., vol vi., p. 384.

JONES, Professor T. R. and J. W. **KIRKBY**. Description of the Species of the Ostracodous Genus Bairdia, M'Coy, from the Carboniferous Strata of Great Britain. *Quart. Jour. Geol. Soc.*, vol. xxxv., pp. 565-581, pls. xxviii.-xxxii.

TIDDEMAN, R. H. Sixth Report on the Exploration of the Settle Caves (Victoria Cave). *Rep. Brit. Assoc.* for 1878, pp. 377-380.

Guide to the Town and District of Sheffield, specially prepared for the Members and Associates attending the Sheffield Meeting of the British Association. (By A. H. GREEN, J. M. MELLO, G. R. VINE, and others.) Edited by J. Taylor, pp. viii, 160. 8vo. Sheffield.

1880.

DE RANCE, C. E. Sixth Report of the Committee . . . . on the Underground Waters . . . . of England . . . *Rep. Brit. Assoc.* for 1880, pp. 87-106.

JUKES-BROWNE, A. J. The Sub-divisions of the Chalk. *Geol. Mag.*, dec. ii., vol. vii., p. 248.

1881.

HUDLESTON, W. H. Contributions to the Palæontology of the Yorkshire Oolites. Parts vi., vii. *Geol. Mag.*, dec. ii., vol. viii., pp. 49-59, 119-131, pls. iii, iv.

PHILLIPS, J. A. On the Constitution and History of Grits and Sandstones. *Quart. Jour. Geol. Soc.*, vol. xxxvii., pp. 6-28, pls. i., ii.

1882.

MEADE, R. The Coal and Iron Industries of the United Kingdom, pp. xxi., 876. 2 Maps, 8vo., *London.*

1883.

Cash, W. Yorkshire Fossil Mollusca. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii , pp. 77-88.

Cole, Rev. E. M. On the White Chalk of Yorkshire. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp. 21-27.

Dakyns, J. R. The Bridlington Crag. *Geol. Mag.*, dec. ii., vol. x., p. 93.

Davis, J. W. On the Fossil Fishes of the Carboniferous Limestone Series of Great Britain. *Trans. R. Dublin Soc.*, ser. 2, vol. i., pp. 327-600, pls. xlii.-lxv.

——— Biographical Notices of Eminent Yorkshire Geologists. I. "John Phillips" *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp. 3-20.

——— Notes on the Occurrence of Fossil Fish Remains in the Carboniferous Limestone Series of Yorkshire. *Ibid*, pp. 39-63.

——— On Some Sections Exposed during the formation of the line of railway between Upton and Kirk Smeaton. *Ibid*, pp. 107-113.

——— Summary of Geological Literature relating to Yorkshire, published during 1882, with Addenda for 1881. *Ibid*, pp. 147-148.

Eddy, J. R. On the Lead Veins in the neighbourhood of Skipton. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp. 63-69.

Hudleston, W. H. Notes on the Excursion to the West Riding of Yorkshire. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii., pp 113-135.

Keeping, W. The Geology of the New Railway Cuttings in the Cave District, South Yorkshire. *Ann. Rep. Yorks. Phil. Soc.* for 1882, p. 45.

——— and C. S. **Middlemiss**. On Some New Railway Sections and other Rock Exposures in the district of Cave, Yorkshire. *Geol. Mag.* dec. ii., vol. x., pp. 215-221,

Lamplugh, G. W. Glacial Sections near Bridlington. Part ii. *Proc. Yorks. Geol. and Polyt. Soc.*, vol. viii. pp. 27-38.

——— Thornwick Bay, Flamborough. *Ibid*, pp. 103-107.

Law, R. and **James Horsfall**. On the Discovery of Flint Implements on the hills between Todmorden and Marsden. *Proc. Yorks. Geol. and Polyt. Soc.*- vol. viii., pp. 70-76.

Mackintosh, D. Results of Observations in 1882, on the Positions of Boulders relatively to the Underlying and Surrounding Ground, in North Wales and North-west Yorkshire; with remarks on the evidence they furnish of the recency of the close of the Glacial Period. *Quart. Jour. Geol. Soc.*, vol. xxxix., *Proc.* pp. 67-69.

Reade, T. M. The Drift-beds of the North-west of England and North Wales. Part ii.—Their Nature, Stratigraphy and Distribution. *Quart. Jour. Geol. Soc.*, vol. xxxix., pp. 83-132, pl. v.

Tew, T. W. On the Recent Extension of Mining Operations under the Permian Formation. *Proc. Yorks. Geol. and Polyt. Soc.* vol. viii., pp. 89-102.

Woodward, Dr. H. Synopsis of the Genera and Species of Carboniferous Limestone Trilobites. *Geol. Mag.*, dec. ii., vol. x , pp. 445 454 and 481-487, pls. xi., xii.

⁂ The Society is much indebted to the kindness of Mr. W. H. Dalton, of H.M. Geological Survey, for his assistance in the above compilation.

LIST OF MEMBERS.

Life Members who have compounded for their annual subscriptions are indicated by an asterisk (*).

*ABBOTT, R. T. G., Auburn Hill, Malton.
ADAMS, THOS., M.A., Underhill, Gateshead.
ADAMSON, S. A., F.G.S., 16, Lovell Terrace, Leeds.
AKROYD, ED., F.S.A., &c., Bankfield, Halifax.
*ALDAM, W., J.P., Frickley Hall, Doncaster.
ALEXANDER, WM., M.D., J.P., Halifax.
ANDERSON, C. P., Cleckheaton.
ATKINSON, J. T., F.G.S., The Quay, Selby.

BAILEY, GEO., 22, Burton Terrace, York.
BAINES, Sir EDWARD, J.P., St. Ann's, Burley, Leeds.
BALME, E. B. W., J.P., Cote Hall, Mirfield.
BARBER, W. C., F.R.G.S., The Orphanage, Halifax.
BARTHOLOMEW, CHAS., Castle Hill House, Ealing, Middlesex.
BARTHOLOMEW, C. W. Blakesley Hall, near Towcaster.
BAYLEY, REV. T., Weaverthorpe.
BEAUMONT, HY., Elland.
BEDFORD, JAMES, Woodhouse Cliff, Leeds.
BEDFORD, J. E., Burley View, Leeds.
BERRY, WM., King's Cross Street, Halifax.
BINGLEY, GODFREY, Ash Lea, Cardigan Road, Headingley.
BINNIE, A. R., F.G.S., M. Inst., C.E., Town Hall, Bradford.
BOOTH, JAMES, F.G.S., The Grange, Ovenden, near Halifax.
BOOTHROYD, W., Brighouse.
*BOWMAN, F. H. D.Sc., F.R.A.S., F.C.S., F.G.S., Halifax.
BRADLEY, GEORGE, Aketon Hall, Featherstone.
BRIERLEY, H. G., Huddersfield.
*BRIGG, JOHN, J.P., F.G.S., Broomfield, Keighley.
*BRIGGS, ARTHUR, J.P., Cragg Royd, Rawden, Leeds.
BROADHEAD, JOHN, St. John's Colliery, Normanton.
BROOKE, ED., jun., F.G.S., Fieldhouse Clay Works, Huddersfield.
BROOKE, Lieut.-Col. THOS., J.P., Armitage Bridge, Huddersfield.

BUCKLEY, GEORGE, jun., Waterhouse Street, Halifax.
BUTLER, J. DYSON, Estate Buildings, Huddersfield.

CAMERON, A. GRANT, of H.M. Geological Survey, 28, Jermyn Street, London, W.
CARR, WM., Halifax.
CARRINGTON, THOMAS, F.G.S., High Hazels, Sheffield.
CARTER, JAS., Burton House, Bedale.
CARTER, R., C.E., F.G.S., Barnsley.
*CASH, W., F.G.S., Elmfield Terrace, Halifax.
CHADWICK, WM., Arksey, Doncaster.
*CHARLESWORTH, J. B., J.P., Wakefield.
CHEETHAM, W., Horsforth, near Leeds.
CHILDERS, J. W., Cantley, near Doncaster.
*CLARK, J. E., B.A., B.Sc., F.G.S., 20, Bootham, York.
COLE, Rev. E. MAULE, M.A., Wetwang Vicarage, York.
COLE, GEO. B., Wakefield Road, Bradford.
CROSS, BENJ. C., C.E., 53, Reginald Terrace, Leeds.
CROSSLEY, LOUIS J., J.P., F.R.M.S., Moorlands, Halifax.
CROWTHER, F., Northowram, near Halifax.

*DAKYNS, J. R., M.A., of H.M. Geological Survey, 28, Jermyn Street, London.
DALTON, THOS., Albion Street, Leeds.
DARTMOUTH, Earl of, Patshull House, Wolverhampton.
DAVEY, HY., Rupert Lodge, Leeds.
DAVIDSON, J., F.C.S., Holywell Green, near Halifax.
*DAVIS, J. W., F.S.A., F G.S., F.L.S., Chevinedge, Halifax.
*DENHAM, CHARLES, London.
DENISON, W. B., J.P., Leeds.
DEWHURST, J. B., Aireville, Skipton.
DODSWORTH, Sir CHARLES, Bart., Thornton Watlass, Bedale.
DOLAN, T. M., M.D., F.R.C.S.Ed., Halifax.
DRURY, ED., Halifax.
DUNHILL, C. H., M.D., Gray's Court, York.
DUNNING, JOHN, F.G.S., Assoc. Inst. C.E., Middlesborough.
DYSON, W. COLBECK, F.S.A., Wilton Park, Batley.

EDDY, J. RAY, F.G.S., Carleton Grange, Skipton.
EDWARDS, Sir HENRY, Bart., J.P., Pye Nest, Halifax.
EFFINGHAM, Earl of, The Grange, Rotherham.
EMBLETON, T. W., C.E., The Cedars, Methley.
EMMOTT, W., The Square, Halifax.

FARRAR, JAMES, Old Foundry, Barnsley.
FILLITER, E., F.G.S., M. Inst., C. E., East Parade, Leeds.
FITZWILLIAM, Earl, K.G., Wentworth Woodhouse, nr. Rotherham.
FLEMING, FRANCIS, Halifax.
FOX, M., jun., Mirfield.
FRAZER, H. J., Fairlea, Wood Lane, Headingley, near Leeds.

GALWAY, The Viscount, Selby Hall, Bawtry.
GARNETT, WILLIAM, Fairlawn, Ripon.
GASCOIGNE, Col. T., Parlington Park, Garforth, near Leeds.
GASCOIGNE, ROWLAND, F.G.S., Denaby Collieries, Mexbro', near Sheffield.
GAUKROGER, W., Fernside, Halifax.
GLEADOW, F., 7, Holker Street, Skipton Road, Keighley.
GOUGH, THOS., B.Sc., F.C.S., Elmfield College, York.
*GRAY, THOS. H., Brookleigh, Calverley, Leeds.
GREAVES, J. O., Wakefield.
*GREEN, Prof. A. H., M.A., F.G.S., 14, Ashwood Villas, Headingley.
GREGSON, W., Baldersby, Thirsk.

HAIGH, JOHN, Eightlands, Dewsbury.
HAILSTONE, E., F.S.A., Walton Hall, Wakefield.
HALIFAX, Viscount, Hickleton Hall, Doncaster.
HALLILAY, J., Burley Road, Leeds.
HANSTOCK, JOHN, Denby Grange, near Wakefield.
HARDCASTLE, JOHN, jun., South Milford.
HAWKING, S., Apperley, near Leeds.
HEATON, J. A., Brighouse.
HELLIWELL, T. W., Brighouse.
HEPWORTH, S. C., West Park Street, Dewsbury.
HESLINGTON, T. C., North Road, Ripon.

HEWITSON, H. B., 11, Hanover Place, Leeds.
HIRST, JOHN, Tadcastle, Dobcross, Saddleworth.
HOLGATE, BENJ., F.G.S., 3, Atkinson Street, Hunslet.
HOLT, H. P., C.E., F.G.S., Fairlea, Didsbury, Manchester.
HORNE, WM., Leyburn.
HOUGHTON, Lord, M.A., D.C.L., F.R.S., Fryston Hall, nr. Pontefract.
HOWGATE, WM., 139, Woodhouse Lane, Leeds.
*HUDLESTON, W. H., Culverden Lodge, Oaklands Park, Weybridge.

KELL, ARTHUR A., Barnsley.
KELL, GEO., Barnsley.
KIRBY, JOEL, Mexbro'.
KIRK, R. S., Leeds.
KNOWLES, G., Leeds Road, Bradford.

*LAMPLUGH, G. W., F.G.S., 2, Claremont Terrace, Bridlington Quay.
LANCASTER, ED., Barnsley.
LAURENCE, JNO., Barnsley.
LAXTON, F., Rastrick, Brighouse.
LEATHER, J. T., Leaventhorpe Hall, near Leeds.
LEE, P. F., West Park Villas, Dewsbury.
LEE, J. BANKS, Ripon.
LEEDS, Duke of. Hornby Castle, Bedale.
LISTER, THOMAS, Victoria Crescent, Barnsley.
LOWTHER, Sir CHARLES, Bart., Swillington Park, near Leeds.
LUPTON, ARNOLD, F.G.S., M. Inst., C.E., 4, Albion Place, Leeds.
LUKIS, Rev. W. C., M.A., &c., The Rectory, Wath, near Ripon.
LUND, PERCY, Ilkley.

MARRIOTT, C. H., J.P., Manor Lawn, Dewsbury.
MARSDEN, THOS., Paper Mills, Barnsley.
MARSHALL, JOHN, F.G.S., Sowerby Bridge, near Halifax.
MARSHALL, STEPHEN, A., B.A., Weetwood, near Leeds.
MASON, C. L., Leeds and County Bank, Leeds.
MAUDE, E., Middleton Hall, Leeds.
MCLANDSBOROUGH, J., F.G.S., F.R.A.S., &c., Manningham, Bradford.

MIALL, Professor L. C., F.G.S., 173, Belle Vue Road, Leeds.
MILNE, S. MILNE, Calverley House, near Leeds.
MITCHELL, JOHN, Swaith Hall, near Barnsley.
MITCHELL, JOSH., F.G.S., Worsbro' Dale, Barnsley.
MITCHELL, T. CARTER, Topcliff, Thirsk
MOISER, H. R., F.G.S., 2, South View, Heworth, York.
MORLEY, GEORGE, Garforth, near Leeds.
*MORRISON, WALTER, J.P., Malham Tarn, near Leeds.
MORTIMER, J. R., F.G.S., Driffield.
MÜLLER, HARRY, Sidcup Hill, Kent.
MYERS, W. BESWICK, 13, Park Square, Leeds.

NELSON, HENRY, St. John's Cottage, St. John's Road, Leeds.
NEWHOUSE, WM. HY., Brighouse.
NORTON, WALTER, J.P., Denby Dale, near Huddersfield.

ORMEROD, HANSON, Boothroyd, Brighouse.
ORMEROD, THOMAS, Brighouse.

PARKE, G. H., F.G.S., F.L.S., Infield Lodge, Furness Abbey.
PARSONS, H. FRANKLIN, M.D., F.G.S., 13, Whitworth Road, South Norwood, London, S.E.
PATCHETT, GEORGE, jun., Halifax.
PEACH, ROBERT, Harrogate.
POCKLINGTON, HENRY, F.R.M.S., Park Row, Leeds.
PRATT, THOMAS, M.R.C.V.S., Ripon.
PRESTON, ALFRED ELEY, C.E., F.G.S., The Exchange, Bradford.

*RAMSDEN, Sir J. W., Bart., M.P., Byram Hall, near Pontefract.
REUSS, F. W., Dewsbury.
REYNOLDS, RICHARD, F.C.S., Cliff Lodge, Leeds.
*RHODES, JOHN, Snydale Hall, Pontefract.
RIGGE, S. T., F.S.A., Balmoral Place, Halifax.
RIPON, The Marquis of, K.G., F.R.S., &c., Studley Royal, Ripon.
ROLLIT, A. K., LL.D., D.C.L., F.R.A.S., F.G.S., &c., Cogan House, Hull.
ROWLEY, WALTER, F.G.S., Albion Street, Leeds.
*RYDER, CHARLES, Westfield, Chapeltown, near Leeds.

SADLER, M. T., M.D., Barnsley.
SCARBOROUGH, GEO., Holly Bank, Halifax.
Scarborough Philosophical Society, J. H. PHILLIPS, (Scarbro').
SCARGILL, ——, East Parade, Sheffield.
SCRATCHERD, T. C., Halifax.
SEAL, STEPHEN, F.G.S., Darfield Quarries, Barnsley.
SHARP, C. FORBES, Driffield.
SHAW, JOHN, Darrington Hall, Pontefract.
SHAW, THOMAS, J.P., M.P., Allangate, Halifax.
SLADEN, W. P., F.G.S., F.L.S., Orsett House, Ewell, Surrey.
SLINGSBY, W. C., Carleton, near Skipton.
SMITH, F., Huddersfield Road, Halifax.
SMITH, WM., F.S.A.S., Osborne House, Morley, near Leeds.
SMITHIES, J. W., Elland.
SORBY, H. C., D.C.L., F.R.S., F.G.S., Broomhill, Sheffield.
STANHOPE, W. T. W. S., J.P., Cannon Hall, Barnsley.
*STANFELD, A. W., Weetwood Grove, near Leeds.
STEEL, R. ELLIOTT, M.A., Spring Cliff House, Heaton Road, Bradford.
STEVENSON, JOHN, Ormesby Packend, Middlesborough.
STOTT, W., Greetland, near Halifax.
STRANGWAYS, C. FOX, F.G.S. of H.M. Geological Survey 5, Belgrave Crescent, Scarborough.
*STRICKLAND, Sir CHARLES W., Bart., Hildenley, Malton.
STUBBINS, JNO., F.G.S., Inglebank, Headingley, Leeds.
SWALLOW, D., Gasworks, Bradford.
SYKES, PEACE, 33, Estate Buildings, Huddersfield.
TATE, THOMAS, F.G.S., 4, Kingston Road, Leeds.
TENNANT, J. R., Kildwick Hall, near Skipton.
TETLEY, Mrs., Foxhills, Weetwood, Leeds.
TETLEY, C. F., Spring Road, Headingley, Leeds.
*TEW, THOMAS W., J.P., Carleton Villa, near Pontefract.
THOMPSON, R., Park Street, The Mount, York.
*TIDDEMAN, R. H., M.A., F.G.S. of H.M. Geological Survey, 28, Jermyn Street, London.
TOWNEND, WALTER, Halifax.
TURNER, R. BICKERTON, J.P., East Parade, Leeds.

VEITCH, W. Y., M.D., 37, Grange Road, Middlesborough.
VILLIERS, J., East Gate, Beverley.
VINE, GEORGE R., 112, Hilltop, Attercliffe, Sheffield.
WALKER, CHARLES, Little Houghton, Darfield.
WARD, CHRISTOPHER, F.L.S., F.Z.S., Halifax.
WARD, GEORGE, F.C.S., Leeds.
*WARD, J. WHITELEY, Halifax.
WARD, JOHN, F.G.S., 23, Stafford Street, Longton, Staffordshire.
WARD, W. SYKES, F.C.S., Denison Hall, Hanover Square, Leeds.
WARRINGTON, JOHN, Rawden, near Leeds.
WENTWORTH, F. T. W. VERNON, Wentworth Castle, Barnsley.
WHARNCLIFFE, Earl of, Wortley Hall, Sheffield.
WHEATLEY, CHARLES, Sand House, Mirfield.
*WHITELEY, FREDK., Clare Hall Road, Halifax.
WILSON, E. J., M.A., 6, Whitefriars' Gate, Hull.
WOOD, W. H., Albion Place, Leeds.
WOOD, W. H., Boro' Analyst, Halifax.
WOODALL, J. W., J.P., F.G.S., Old Bank, Scarbro'.
WOODHEAD, JOSEPH, J.P., Woodthorpe, Huddersfield.

⁂ It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1883.

Computed from daily observations made at the Exchange, Bradford.

By John McLandsborough, F.R.A.S., F.R. Met. Soc., F.G.S., and Alfred Eley Preston, Assoc. M. Inst. C.E., F.R. Met. Soc., F.G.S.

Latitude, 53 deg. 47 min. 38 sec. N.; longitude, 1 deg. 45 min. 4 sec. W. Height above mean sea level, 366 ft.

Months	Pressure of Atmosphere in Month: Highest Reading of Barometer	Date	Mean of Highest of 15 Years	Lowest Reading of Barometer	Date	Mean of Lowest of 15 Years	Range	Corrected for Capillarity and Temperature: Mean	Mean of 15 Years
	Ins	On	Ins	Ins	On	Ins	Ins	Ins	Ins
January	30.212	29th	[illegible]	28.499	6th	[illegible]	1.720	29.505	29.524
February	30.160	2nd	[illegible]	[illegible]	5th	28.742	1.1?2	29.655	29.497
March	30.229	4th	30.1?1	28.?0?	9th	[illegible]	1.?21	29.640	29.5?1
April	30.360	9th	[illegible]	[illegible]	1st	[illegible]	1.411	[illegible]	29.489
May	[illegible]	17th	[illegible]	[illegible]	10th	[illegible]	[illegible]	[illegible]	29.570
June	[illegible]	[illegible]	30.??9	[illegible]	26th	29.141	[illegible]	29.516	29.532
July	[illegible]	5th	30.0?0	29.?12	9th	29.117	[illegible]	[illegible]	29.518
August	30.1?3	22nd	[illegible]	[illegible]	1?th	28.???	[illegible]	29.514	29.5?1
September	30.004	1?th	30.1?1	28.452	[illegible]	28.???	1.512	29.4??	29.490
October	30.311	3rd	30.1??	28.?64	16th	28.?41	1.310	29.45?	29.447
November	29.944	1st	30.?91	28.???	25th	28.???	1.4??	29.???	29.422
December	30.2?6	[illegible]	30.1??	[illegible]	14th	28.??7	1.1?	29.6?7	29.4?6
Means, or totals	[illegible]		30.1??	28.???		28.??0	1.98?	29.5??	29.491

Months	Temperature of Air in Month: Highest	Date	Mean of Highest of 15 Years	Lowest	Date	Mean of Lowest of 15 Years	Range	Mean: Of all Highest	Mean of 15 Years	Of all Lowest	Mean of 15 Years	Daily Range: Mean	Mean of 15 Years	Of Dry Bulb: Mean	Mean of 15 Years
	Deg	On	Deg	Deg	On	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
January	51.1	2nd	5?.?	23.6	31st	23.1	27.5	43.8	43.?	35.7	34.2	8.1	8.8	40.0	39.3
February	54.0	2nd	5?.?	27.8	1st	27.1	26.2	46.2	44.6	38.0	35.7	8.2	?.9	42.4	40.2
March	51.4	[illegible]	56.6	16.8	10th	26.1	34.6	41.6	47.0	29.9	35.6	11.7	11.4	35.1	40.?
April	6?.?	13th	65.1	32.?	25th	31.7	31.7	53.7	53.6	39.2	4?.?	14.5	13.5	46.0	45.?
May	[illegible]	17th	[illegible]	3?.0	5th	31.6	38.6	[illegible]	58.?	4?.?	43.7	15.1	14.8	50.1	49.6
June	75.?	16th	76.?	44.0	4th	41.9	31.3	64.3	65.2	49.9	50.1	14.4	15.1	5?.2	55.3
July	76.2	3rd	?.4	45.8	15th	47.1	30.4	65.9	68.8	52.2	54.0	13.7	14.8	57.5	60.5
August	74.2	26th	73.7	49.0	23rd	46.?	25.2	67.4	6?.?	53.2	5?.?	14.2	14.4	58.3	59.?
September	65.7	19th	7?.7	44.1	9th	46.?	21.6	61.7	6?.?	50.7	5?.?	11.0	12.6	55.1	54.5
October	62.4	9th	64.?	[illegible]	22nd	32.6	2?.3	54.2	54.3	44.3	43.5	9.9	10.8	48.6	4?.5
November	56.2	20th	56.2	29.2	12th	26.4	27.0	46.9	47.2	38.2	38.0	8.7	9.2	42.6	42.7
December	54.0	14th	53.2	29.0	7th	22.9	25.0	45.1	42.6	37.1	34.2	8.0	8.4	41.3	39.1
Means, or totals	6?.7		64.0	?1.5		??.5	?9.2	51.?	54.6	4?.7	42.7	11.4	11.9	4?.?	48.0

Months	Adopted Mean Temperature: Of Air: Mean	Mean of 15 Years	Of Evaporation: Mean	Mean of 15 Years	Dew Point: Mean	Mean of 15 Years	Vapour: Elastic Force: Mean	Mean of 15 Years	In a Cubic Foot of Air: Mean	Mean of 15 Years	Short of Saturation	Mean of 15 Years
	Deg	Deg	Deg	Deg	Deg	Deg	Ins	Ins	Grs	Grs	Grs	Grs
January	39.?	38.8	38.3	37.1	36.3	34.7	.215	.204	2.5	2.4	0.4	0.4
February	42.0	40.?	40.0	38.3	37.5	36.0	.225	.21?	2.6	2.5	0.6	0.4
March	34.9	40.5	3?.4	38.2	31.0	35.3	.173	.207	2.0	2.4	0.4	0.5
April	4?.?	45.4	41.5	42.0	36.9	38.1	.22?	.23?	2.8	2.7	0.5	0.8
May	49.8	49.5	45.2	45.1	4?.?	41.0	.2?1	.2?8	2.9	3.0	1.2	1.1
June	55.2	55.?	50.5	5?.3	4?.0	46.9	.??2	[illegible]	3.5	3.6	1.4	1.?
July	57.5	60.3	53	54.?	4?.5	5?.5	.3?1	[illegible]	3.9	4.1	1.4	1.7
August	55.4	5?.?	5?.?	54.4	?1.9	?.7	.3??	[illegible]	4.3	4.2	1.2	1.5
September	55.0	54.6	[illegible]	51.5	51.7	4?.2	.383	[illegible]	4.3	3.8	0.6	1.0
October	48.4	48.9	46.6	45.8	43.4	4?.1	.2?1	.279	3.2	3.2	0.6	0.6
November	42.4	4?.2	39.9	40.0	36.8	37.1	.219	.222	2.6	2.6	0.6	0.5
December	41.2	38.7	39.1	36.7	36.5	31.3	.215	.200	2.5	2.3	0.6	0.4
Means, or totals	4?.5	47.8	44.6	44.0	41.5	41.3	.270	.26?	3.1	3.1	0.8	0.9

Months	Degree of Humidity (Complete Saturation = 100): Highest	Date	Mean of Highest of 15 Years	Lowest	Date	Mean of Lowest of 15 Years	Mean	Mean of 15 Years	Mean Weight of a Cubic Foot of Air	Mean of Fifteen Years	Highest Reading of Maximum Thermometer in Rays of Sun	Date	Mean of Highest of Fifteen Years	Mean Reading of Maximum Thermometer in Rays of Sun	Mean of Fifteen Years
	0–100	On	0–100	0–100	On	0–100	0–100	0–100	Grs	Grs	Deg	On	Deg	Deg	Deg
January	98	29th	9?	73	18th	67	88	86	545	549	53.4	27th	60.7	51.3	48.?
February	97	8th	97	60	28th	70	85	86	546	547	81.7	26th	73.1	56.6	62.?
March	97	20th	96	59	6th	58	75	83	5?4	547	78.2	6th	85.?	66.2	72.4
April	96	25th	94	30	9th	55	65	78	5?3	540	9?.2	10th	9?.6	79.6	74.2
May	93	12th	9?	35	16th	47	70	73	527	5?7	107.0	17th	1?7.3	81.0	89.0
June	97	26th	9?	46	5th	51	71	72	531	53?	105.8	14th	11?.7	84.9	8?.2
July	94	3rd	90	43	1st	51	74	70	520	5?6	103.0	20th	1?.0	8?.1	92.5
August	96	2nd	92	51	20th	53	79	75	527	526	107.0	4th	112.6	85.6	[illegible]
September	97	29th	95	59	2?th	58	89	79	528	5?0	87.8	10th	10?.8	7?.1	60.6
October	96	24th	97	58	2nd	63	83	83	537	537	80.0	?th	87.2	65.9	?.0
November	95	21st	96	62	29th	64	81	83	542	543	?6.0	6th	71.3	51.0	?1.1
December	99	26th	93	67	4th	65	84	84	549	548	57.6	2nd	5?.3	41.5	46.5
Means, or totals	96		94	54		59	81	[illegible]	[illegible]	5?8	8?.1		9?.?	6?.1	70.?

Months	Wind: Highest Estimated Strength	Date	Mean Estimated Strength	Direction: Relative Proportion of each: N	NE	E	SE	S	SW	W	NW	Mean Amount of Cloud
	0–6	On	0–6	No	No	No	No	No	No	No	No	0–10
January	4.?	2?th	1.0	0	1	0	6	0	11	4	7	7.5
February	2.5	11th	1.0	0	0	0	6	4		5	5	7.0
March	2.5	30th	1.0	0	7	2	6	0		1	12	6.3
April	?.5	23rd	0.?	6	0		6	0		11	5	6.?
May	2.0	2?d	1.0	0	8	?	0	1		?	7	5.?
June	2.0	[illegible]	0.8	0	6	6	?	1	?	2	2	6.?
July	?.0	2?th	1.0	0	3	0	2	5	?	13	1	6.?
August	3.5	?th	1.0	6	1	6	0	5	11	11	4	6.0
September	[illegible]	?th	1.2	1	8	1	6	0	1	?	6	[illegible]
October	3.5	29th	1.2	3	5	0	?	0		2	9	7.2
November	2.5	4th	1.1	0	3	0	?	?	1	0	8	7.1
December	?.?	12th	1.5	3	?	1	1	0		7	10	7.3
Means, or totals	2.8		1.1	?	31	1?	49	16	1?	?6	79	[illegible]

Months	Rain: Number of Days of Rain	Amount collected	Greatest Daily Fall	Date	Mean of Fifteen Years	Mean of Seven Years ending with 1882, at Exchange	Mean of Seven Years ending with 1882, at Town Hall and Midland Station on surface of ground	Greater fall on surface of Town Hall & Mid Stn than at 65 ft above surface at Exch: Depth in Inches	Percentage of Fall at Exch'ge
	No	Ins	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	22	[illegible]	[illegible]	23rd	2.61?	[illegible]	[illegible]	0.?65	11.2
February	16	1.7?	0.2?	7th	2.01?	[illegible]	[illegible]	[illegible]	11.1
March	13	0.??	[illegible]	7th	[illegible]	[illegible]	[illegible]	[illegible]	11.?
April	9	[illegible]	[illegible]	25th	[illegible]	[illegible]	[illegible]	[illegible]	11.2
May	1?	[illegible]	0.13?	11th	1.8?	[illegible]	[illegible]	0.174	1?.8
June	11	[illegible]	[illegible]	2?th	[illegible]	[illegible]	[illegible]	?.174	[illegible]
July	2?	[illegible]	1.0?	31st	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August	1?	[illegible]	[illegible]	[illegible]	2.?1	[illegible]	[illegible]	[illegible]	10.7
September	22	[illegible]	1.??	26th	[illegible]	[illegible]	[illegible]	0.?35	11.2
October	18	[illegible]	0.71	17th	[illegible]	[illegible]	4.?1?	[illegible]	11.0
November	2?	[illegible]	0.1?	5th	[illegible]	[illegible]	[illegible]	0.4?7	11.?
December	1?	[illegible]	0.2?	11th	2.9?	[illegible]	[illegible]	[illegible]	11.8
Means, or totals	206	[illegible]	[illegible]		[illegible]	35.?11	[illegible]	[illegible]	[illegible]

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, AND RAINFALL. FROM 1869 TO 1883 INCLUSIVE.

EXPLANATION

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded, whilst the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level, the air temperature being fifty degrees and barometer reading 30 inches at sea level, add ·401 inch to the heights given.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

The solar thermometer has a black bulb enclosed in vacuum.

The direction of the wind as recorded is indicated by vane, and not by the clouds. Its pressure is estimated by a scale ranging from 0 to 6, the square of the number giving, approximately to the [illegible], the pressure in pounds per square foot. The highest number of scale indicating 36lb. per foot has not hitherto been recorded at the Exchange, while at some more exposed meteorological stations in this country much greater pressures have been recorded by anemometer. Provision has been made for registering the direction and pressure of wind by anemometer from commencement of 1884.

The amount of cloud is estimated by a scale ranging from 0 to 10.

Year	Pressure: Highest: Reading of Barometer during Year	Date	Lowest: Reading of Barometer during Year	Date	Temperature: In Shade: Highest: Reading of Maximum Thermometer during Year	Date	Lowest: Reading of Minimum Thermometer during Year	Date	Last and First Frost of Season: Date of Last Frost	Date of First Frost	In Sun's Rays: Highest: Reading of Solar Thermometer during Year	Date	Humidity (Complete Saturation = 100): Highest: Degree of Humidity during Year	Date	Lowest: Degree of Humidity during Year	Date	Rain: Total for Year	Mean Yearly Rainfall at Town Hall and Midland Railway Station on surface of ground	Greater fall on surface at Town Hall & Mid Rly Stn than at 65½ ft above surface at Exchange: Depth in Inches	Percentage of Fall at Exch'ge	Greatest Daily Fall during Year	Date	Snow: Last and First Snow of Season: Date of Last Snow	Date of First Snow
	Ins		Ins		Deg		Deg				Deg		0–100		0–100		Ins	Ins	Ins	Per cent	Ins			
1869	30.290	Dec 6	28.500	Feb 1	85.2	Aug 30	19.3	Dec 28	Mar 27	Oct 20	127.7	Aug 30	99	Feb 8	42	Sep 24	24.496				0.670	Dec 18	April [illegible]	Oct 9
1870	30.204	Jan 19	28.4?3	Jan 8	85.0	July 26	16.6	Dec 23	Mar 30	Nov 9	127.5	July 25	98	Jan 29	40	July 14	24.120				0.820	June 18	Mar 24	Nov 15
1871	30.152	Mar 28	28.406	Jan 16	84.0	Aug 12	6.7	Jan 1	April 11	Nov 13	128.7	July 17	98	July 7	43	Nov 2	21.640				0.985	June 16	Mar 15	Nov 16
1872	30.156	April 6	28.070	Jan 24	86.4	July 23	24.8	Mar 27	Mar 27	Nov 19	124.6	Aug 19	100	Mar 22	45	Sep 23	42.060				2.490	June 19	Mar 11	Nov 13
1873	30.?43	Feb 15	28.022	Jan 20	86.8	July 23	19.2	Feb 24	Mar 14	Nov 5	124.5	July 23	100	Dec 11	41	Mar 26	23.440				1.2?0	Aug 4	April 25	Jan 3, '74
1874	30.476	Mar 6	28.276	Dec 11	80.9	July 20	15.0	Dec 31	Mar 12	Nov 11	125.6	July 20	100	Feb 6	42	May 18	23.560				0.?10	Dec 7	May 9	Nov 26
1875	30.405	July 7	28.484	Nov 10	80.0	Aug 17	13.0	Jan 1	Mar 22	Nov 26	122.0	July 5	100	Jan 23	43	July 6	30.2?0				1.?0	Nov 15	Mar 12	Nov 9
1876	30.300	Jan 15	28.073	Dec 4	87.6	July 17	23.0	Jan 9	April 15	Nov 9	125.6	July 16	99	Oct 4	46	May 5	35.2?0	3?.788	4.518	11.28	1.610	Oct 9	April 13	Nov 8
1877	30.358	Oct 6	28.300	Nov 29	80.0	June 19	20.0	Mar 1	May 4	Oct 18	116.4	June 19	100	Oct 29	35	May 21	40.?5?	45.4?0	4.849	11.19	1.420	July 16	May 1?	Oct 15
1878	30.320	Mar 16	28.630	April 1	89.6	July 19	13.3	Dec 26	April 6	Nov 9	118.2	July 22	90	Jan 13	53	Aug 9	35.144	39.010	3.576	11.01	1.220	Aug 14	April 1	Nov 8
1879	30.352	Dec 13	28.500	Feb 10	74.4	July 30	13.2	Dec 7	May 13	Nov 14	101.2	Aug 13	100	Oct 7	51	Dec 12	28.017	30.2?8	2.281	10.82	1.020	June 8	May 7	Nov 20
1880	30.332	Jan 7	28.154	Nov 16	81.3	Sep 5	20.8	Jan 20	Feb 23	Oct 20	112.0	Aug 13	99	Dec 15	50	May 30	35.6?6	39.116	3.926	11.10	1.710	Oct 27	Mar 2	Oct 27
1881	30.382	May 10	28.250	Oct 14	83.3	July 6	12.0	Jan 26	April 21	Oct 17	116.6	June 1	98	Oct 14	38	May 31	35.434	39.692	4.468	11.26	1.435	Oct 13	April 20	Oct 29
1882	30.544	Jan 18	28.452	Mar 1	77.4	Aug 12	18.6	Dec 11	April 16	Nov 12	108.0	Aug 9	99	Nov 5	36	May 18	39.663	43.103	3.420	10.86	1.606	Dec 6	Mar 21	Nov 11
1883	30.500	April 9	28.452	Sep 2	76.2	July 3	19.8	Mar 10	Mar 29	Nov 12	107.6	May 17	99	Dec 26	30	April 9	34.596				1.348	Sep 26	Mar 24	Nov 16
Means	30.330		28.316		82.7		17.1				119.1		99		42		31.477	39.001	3.860	11.06	1.358			

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 495 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were procured and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gauges are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·860 inches, or 11·06 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the fifteen years ending with 1883 is 31·477 inches. By adding 11·06 per cent. thereto the mean yearly rainfall of central Bradford for such period is found to be [illegible] inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange and on buildings generally than on the surface of ground is due to the varying direction and force of wind thereon producing different currents and eddies, which prevent the precipitation on the top or edge of roof where the gauge is fixed.

All the instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

New Series, Vol. VIII., Part III., pp. 295 to 423.

With Eight Plates and Title Page.

Edited by JAMES W. DAVIS, F.S.A., F.L.S., F G S.

1884.

YORKSHIRE

Geological and Polytechnic Society.

President:

The Marquis of Ripon, K.G., &c.

Vice-Presidents:

Duke of Leeds.
Earl of Dartmouth.
Earl of Effingham.
Earl Fitzwilliam.
Earl of Wharncliffe.
Lord Houghton.
Viscount Halifax.
Viscount Galway.
Louis J. Crossley, J.P.,
Walter Morrison, J.P.,
Thos. Shaw, M.P.
H. C. Sorby, LL.D., F.R.S.
W. T. W. S. Stanhope, J.P.
Thos. W. Tew, J.P.

Treasurer:

William Cash, F.G.S.

Honorary Secretary:

James W. Davis, F.S.A., F.G.S., &c., Chevinedge, Halifax.

Council:

W. Alexander, M.D.
J. E. Bedford.
R. Carter, C.E.
W. Cheetham.
J. R. Eddy, F.G.S.
T. W. Embleton, C.E.
E. Filliter, C.E.
Prof. A. H. Green, M.A.
G. H. Parke, F.G.S.
R. Reynolds, F.C.S.
W. Rowley, F.G.S.
W. S. Ward, F.C.S.

Local Secretaries:

Thos. Lister, Barnsley.
Thos. Tate, F.G.S., Bradford.
G. W. Lamplugh, F.G.S., Bridlington.
P. F. Lee, Dewsbury.
Rev. E. M. Cole, M.A., F.G.S., &c., Driffield.
George Patchett, jun., Halifax.
Peace Sykes, Huddersfield.
G. J. Wilson, M.A., &c., Hull.
Geo. Paul, F.G.S., Leeds.
Dr. W. Y. Veitch, Middlesbrough.
J. T. Atkinson, F.G.S., Selby.
W. Gregson, Thirsk.
Wm. Horne, Wensleydale.

PROCEEDINGS OF THE YORKSHIRE
Geological & Polytechnic Society.

VOL. VIII., PART III.
WITH EIGHT PLATES.

EDITED BY JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

1884.

CONTENTS.

PAPERS:— PAGE.

"'Biographical Notices of Eminent Yorkshire Geologists. III., 'John Williamson.'" By W. C. Williamson, LL.D., F.R.S., &c., Professor of Botany at the Owen's College, Manchester. 295
"On the Mineral Wells at Harrogate." By Richard Carter, C.E., F.G.S. ... 313
"The Harrogate Wells, or the Mineral Waters of Harrogate geologically considered." By C. Fox-Strangways, F.G.S., &c., of H.M. Geological Survey. 319
"The Mineral Springs of the Grand Anticlinal of the West Riding: a few Chemico-Geological Notes." By Geo. Oliver, M.D. (Lond.) ... 336
"The Mineral Wealth of Harrogate." By R. Hayton Davis, F.C.S. ... 357
"Analysis of the Kissengen Saline Chalybeate Water, 1883, as compared with analyses in 1845, 1854, 1867, and 1879." By R. Lloyd Whiteley. Student in the Yorkshire College. 366
"Contributions to the Fossil Flora of Halifax." Part IV. By Thos. Hick, B.A., B.Sc., and William Cash, F.G.S. 370
"Further Notes on New Species, and other Yorkshire Carboniferous Fossil Polyzoa described by Prof. John Phillips." By George Robert Vine 377
"On the Composition of the Coal Balls and Baum Pots in the Lower Coal Measures." By H. B. Stocks 393
"On the Fire-Damp Detector, with recent Improvements in the Miners' Safety Lamp; and some remarks on the difficulties connected with Deep Mining." By W. E. Garforth, C.E. 395
"On a new Species of Heterolepidotus from the Lias." By James W. Davis, F.G.S., &c 403
Secretary's Report and Balance Sheet 408
Minutes 412
Summary of Geological Literature relating to Yorkshire, published during 1884, with addenda for 1880–1883 415
List of Members 417
Meteorology of Bradford for 1884. By J. McLandesborough, F.G.S., and A. E. Preston, F.G.S. 424

LEEDS:
PRINTED BY A. MEGSON AND SONS,
1885.

VOL. VIII.] [PART III.

PROCEEDINGS
OF THE
YORKSHIRE
GEOLOGICAL AND POLYTECHNIC SOCIETY.

EDITED BY JAMES W. DAVIS, F.S.A., F.G.S., &c.

1884.

BIOGRAPHICAL NOTICES OF EMINENT GEOLOGISTS: III. "JOHN WILLIAMSON." BY W. C. WILLIAMSON, LL.D., F.R.S., ETC., PROFESSOR OF BOTANY AT THE OWENS' COLLEGE, MANCHESTER.

To form a right estimate of the work done by the subject of this memoir, we must recall to mind the state of Geological science at the time when he commenced his labour. The contest between the schools of Hutton and Werner, then at its height, referred chiefly to questions of Physical Geology. Palæontology attracted but little attention, and as little was known of the relative ages and true succession of rocks. Yet early in the eighteenth century, Strachey had thrown light upon that succession, so far as it was displayed in some of the strata above the coal in Somersetshire; and Michell, then Woodwardian Professor of Geology in Cambridge, worked out the relative positions of some of the strata ranging from the Carboniferous beds of Western Yorkshire, to the Chalk of Cambridge; but never having published these results in any definite form, Michell failed to obtain the credit to which his important researches entitled him.*

William Smith was born during the lifetime of Michell, but derived no advantage from his investigations, being then wholly ignorant of the work done by the Cambridge Professor. Smith commenced his investigations in the latter part of the eighteenth century, following, in many respects, the steps of Michell, but with very different results. Single-handed, he not only worked out, with marvellous accuracy, the succession of the strata from the Chalk to the Coal-measures, but he made the great discovery that, so far as Great Britain was concerned, rocks of contemporary origin contained identical fossils; in other words, that special organic remains were limited to particular strata, under conditions proving that varied forms of life had successively existed on the earth, each epoch being characterised by the prevalence of special types, which replaced one another as time rolled on.

---

* Phillips' memoir of William Smith, LL.D., p. 139.

Smith's researches, as is well-known, culminated in 1817, when he published his celebrated work, "Strata identified by organised Fossils." Those researches, as already indicated, were mainly pursued amongst the Carboniferous and Mesozoic strata. No part of England, probably no part of the world, displays in so small a compass such an unbroken succession of the Cretaceous, Oolitic, and Liassic beds, as is revealed in the precipitous cliffs that overhang the shore from Flamborough Head to Skinningrave. It was scarcely possible that such a coast should fail to call into existence a band of local geologists, even in the infancy of geological science; nor did it do so, and John Williamson was one of the earliest to enter the field. The names of three other men must be associated with his; those of his cousin, William Bean; the Rev. George Young, of Whitby; and Mr. John Bird, the artist who drew the figures of the fossils for Young and Bird's work, published at a later period. Four men whose united labours in unearthing the relics of bygone ages, assisted in giving the study of Yorkshire Geology an impetus, and in stamping it with an importance, it had not hitherto known.

I should at any time have had pleasure in recalling memories of my father, for the benefit of succeeding geologists; but the fact that this year is the centenary of his birth, makes my doing so now more than ordinarily agreeable.

Peasant families rarely possess historic records of their ancestry; my knowledge of our own is limited to a few lines in a letter written by my father, in which he tells me that his only recollections of my great-grandfather, is that of an old man living in a small cottage in the village of Fridaythorpe, on the Yorkshire Wolds. My grandfather, born at Fridaythorpe, was for many years shepherd to some of the large farmers of that district; he was a hard-working, saving man, who took little pleasure beyond an annual visit to York, or an evening chat with friends at the Fridaythorpe Inn where

"Village statesmen talked with looks profound,
And news much older than their ale went round."

Of this Inn the young shepherd presently became landlord. His business frequently took him to Driffield, where he met with his future wife, Mary Bean, the sister of a market gardener (the father of Wm. Bean, the geologist), who resided at Brompton, near Scarborough. After marriage, the young couple lived at the Fridaythorpe Inn for several years, and here John Williamson was born in 1784. Not finding the Inn financially successful, the family removed to Scarbrough, whither, meanwhile, the Brompton gardener had also removed, having purchased an extensive plot of land. This purchase, as the possession of one naturalist, and the training ground of another, acquires some interest to us. It appears to have been bounded by what is still Huntress Row; by the road leading from the southern end of that row through Belvoir Terrace nearly to the "Plantation;" by a line parallel with the Plantation itself; and by the York Road from the northern end of that line to the corresponding end of Huntress Row. This plot, now of almost priceless value, was then purchased for a few hundreds of pounds. Mr. Bean laid it out partly as a market garden, and partly as a subscription strawberry garden, in which latter capacity it became the fashionable promenade of the watering place. A relic of these gardens existed in my own boyhood, in which I bought fruit on Sundays, and cabbages for my rabbits on week-days. The death-knell of these gardens was sounded in 1826, when the foundation stone of Christ Church was laid in their very centre.

At the age of about nine years, my father was sent to work in these gardens under the care of his uncle, their proprietor. As may well be supposed, ordinary education had done but little for him; I believe that he received no instruction save what he obtained at a Sunday School, in which, as was happily the wont in those days, reading and writing were taught. After working two years in these gardens, he was regularly apprenticed for seven years more, but his uncle died before the expiration of that period. Young as he then was, the management of the concern fell upon his shoulders, and he retained it until he was eighteen or nineteen years of age, when, wishing to extend his knowledge of the higher branches of practical gardening in some different school, he left Scarbrough to become under gardener at Wykeham Abbey, the seat of the Langley's, a few miles from the town; here he remained three years, at the end of which time he was appointed head gardener to the Earl of Mulgrave, whose Castle was at Lyth, near Whitby. I have often heard my father tell how he left Wykeham Abbey by a back door, having but five shillings in his pocket, a parting gift from old Mrs. Langley. He married soon after going to Lyth, which became his home for the next seven years. His young bride was the eldest of thirteen children of Alexander Crawford, a jeweller and watchmaker of Scarbrough, a thorough-going Scotchman of the old school, a believer in second sight and other myths so widely accepted by the Scottish peasantry. Mr. Crawford's history was not devoid of dramatic touches. A native of the Lowlands north of the Lammermuirs, his first trade was that of a slater; whilst working as such he one day fell through a roof, but his feet having caught some projection he hung head downwards until help came. After this he went to Edinburgh and exchanged his craft for that of a watchmaker and jeweller. Circumstances soon transpired making it desirable for him to quit Scotland. Long after the events of '45, the officers in command of Government troops stationed in Scotland were apt to indulge in a cavalier treatment of the native population. On some such occasion Crawford and one of his patriotic fellow-countrymen resented this treatment in a very practical manner; but cool reflection soon convinced the youths that military discipline would probably bring swift punishment upon them for their rebellious patriotism, and they thought it safest to cross the Tweed and hide themselves in

England. They made their way, first to Whitby, and afterwards to Scarborough, where Alexander Crawford was residing when my mother was born. Thirteen children and limited finances made it necessary for each member of the family to work; my mother, the oldest daughter, early hired a room in her fathers house and sustained herself by dress-making, which calling she pursued until my father persuaded her to share his home and fortunes at Lyth.

Even in the days of his courtship, the energy which was so characteristic of John Williamson throughout his future life made itself manifest. Anxious to spend some of his Sundays with his betrothed, and there being but few conveyances in those days between Whitby and Scarbrough, he not unfrequently left the gardens of the Castle after six o'clock on Saturday evening, and walked to Scarbrough during the night; enjoyed the day in Miss Crawford's society, and walked back to Mulgrave during the second night, in time to be at the gardens at six o'clock on Monday morning.

In was during his residence at Mulgrave that my father's thoughts were first seriously directed to any branch of scientific study, and British Botany appears to have been the first to engage his attention. The district was a likely one to further such a pursuit. The coast-line abounded in maritine plants, whilst the woods of Mulgrave, the swampy vale of the Esk, and the overhanging brows of the Yorkshire Moorlands, offered rich supplies of native plants. The local herbarium which he prepared at that time, came into my hands at a later period, and gave proof of the care with which he had pursued the study; but another subject attracted some attention at the same period. In those early days when geology had but few votaries, the Yorkshire coast furnished rich harvests both of fossils and "pebbles" which had laid for ages undisturbed and almost unnoticed. The term "pebbles," then comprehended the various siliceous and felspathic stones known by the names of Carnelian, Fortification-agate, Onyx, Tube-agate, Mocha, Moss-agate, Jasper, Heliotrope or Bloodstone and Adularia or Moon-stone. Many of these were originally siliceous constituents of antient fluid lavas, but which as the lavas cooled, separated themselves from the Augitic portion, and formed Amygdaloidal concretions. The decomposition of the Augite, by various agencies, liberated these harder stones. Others of them were fragments of metamorphosed stratified rocks. The original home of most of these stones was Scotland and other Northern regions, whence they were brought southward by the several glacial agencies to which the Drift or boulder clays of Yorkshire coast owed their existence. Such of these clays as were within the reach of the sea were undergoing constant waste, causing the shore to be strewed with the hard shingle with which the clays abound. The gravel of the bay extending northward from Whitby to the village of Sandsend were formerly rich in these "pebbles," as the bay afforded a convenient route for pedestrians between Lyth and Whitby, it was frequently crossed by the young gardener, who was too observant not to detect such specimens as were worth collecting; his connection with the jeweller's family would give him an additional interest in these stones, since they were in demand to be manufactured into brooches and other ornaments. Many of the agates were exquisitely beautiful; but one large *Mocha*, by whom collected is not now known, stood out from the rest under the name of the York Minster agate, because of the resemblance which the sections of it have to the coloured glass of the Minster windows. A slice of this fine stone is still, I believe, in the Museum of the Scarborough Philosophical Society.

But Williamson's attention could not long be limited to these transported pebbles. As is well-known, the lofty cliffs and flat scars extending for miles north and south of Whitby, mainly consist of Liassic beds extremely rich in fossil remains; but those fossils are now much less easily obtained than was the case even in my own earlier days. Whether conspicuously exposed, or embedded in hard rounded concretions, they then stood out from the softer tide-worn strata which enclosed them in great numbers. An hour or two spent on the shore below the Lyth Alum Works, would then have furnished more superb fossils than we could have carried away with us. Hard nodules abounded, half embedded in the shale. Some of these contained fine specimens of the Ammonites annulatus and communis. Others enclosed the large chambered phragmocones of Belemnites, the guards of which protruded from one end of the nodule and lay resting on the soft shale. On other parts of the shore, broad expanses of similar shales were almost hidden from view by masses of smaller Belemnites, which lay closely packed side by side. Such sights as were familiar to my young eyes, are no longer to be seen on that coast; but when my father was young, such fossils were yet more abundant. The tidal washing of ages had laid them bare, but no one cared to notice, much less to gather them. The untutored public only saw "thunderbolts" in the Belemnites, and snakes, turned into stone by St. Cuthbert, in the Ammonites. These explanations being deemed unquestioned truths, nobody was concerned to trouble their heads further about the stones, beyond an occasional expression of wonder as to what the "snakes" had done with their missing heads.

At the end of seven years, Mr. Williamson left the service of the house of Mulgrave. The Earl, who had married into a family of a rank somewhat different from his own, was annoyed by circumstances that had occurred in the gardens. My father knew that some young lads, relatives of the Countess, were the offenders on the occasion, but he also knew that to denounce them to the Earl, would make the Countess his enemy for life. He therefore adopted the wiser course of throwing up his appointment and returning to Scarbrough.

When my father left Scarbrough for Wykeham Abbey, William Bean, the future naturalist, took charge of the gardens which he had inherited; but the work accorded neither with his tastes nor his talents; hence he readily availed himself of his cousin's return from the North, to engage him as manager of the concern. This position he continued to hold up to the time when Mr. Bean retired from business. My father then established himself as a gardener, taking charge of the gardens of several of the leading gentry of the town, whose grounds were not sufficiently extensive to require the services of a permanent servant. This work left him more freedom than he had hitherto enjoyed, and he devoted his increased leisure, to the collection of the fossils and recent shells of Eastern Yorkshire. This was not seldom done when wet weather made work in the gardens impossible; fly-fishing frequently sharing with fossil-hunting in the use to which he put these rainy days. Returning from one of these excursions with saturated garments, he unfortunately paused for a few minutes at the door of a wayside inn, became chilled, and only reached home to be prostrated by a severe attack of inflammation of the lungs. In consequence of this attack, aided, doubtless, by the fearful and repeated bleedings which the medical practice of those days authorised, he was for six months a disabled invalid. A remarkably vigorous constitution, however, enabled him to survive the dangers to which nature and art had combined to expose him. So soon as his strength admitted, wet days again found him throwing the fly, or wielding the geological hammer.

The remarks already made respecting the virgin field which the Liassic rocks north of Whitby offered for the researches of the geologist, were, at that time, yet more applicable to the coast for 20 miles north and south of Scarborough. Here the rocks are of a more varied character than in the cliffs further north, comprehending as they do, a fine series of the Oolitic strata which overlap the more northern Liassic beds, and are themselves overlaid by the Cretaceous deposits at the southern end of Filey Bay.

Thomas Henderson, the distinguished historian of the town, had collected a few fossils of small importance, but he was in no sense of the word, a geologist. In the latter part of the seventeenth century, the well-known Lister had noticed some of the fossils found in the Speeton cliffs, but no systematic exploration of the coast had been attempted until my father and William Bean commenced those labours that were destined to extend over half a century.

Prior to the discoveries of William Smith, no one seems to have appreciated the geological importance of the Oolitic rocks. Smith had studied them carefully in the district round Bath, and had traced their out-crop running in a north-easterly direction, towards their termination on the coast between Burlington and Skinningrave. He was familiar too, with their more common fossils, but their fauna and flora, as a whole, had yet to be studied. Fortunately for the Yorkshire geologists, most of those rocks are exposed on their coast with a concentration, as well as exact sub-division of their strata, that probably has no parallel in any other part of the globe. Nor is this the only geological feature that makes this coast so interesting.

The Speeton clay, in which the Cretaceous and Oolitic strata are blended in an apparently unbroken continuity, and from which such palæontological treasures were destined to be drawn, was as yet an unexplored mine. Hence the two young geologists entered into the possession of a palæontological estate of rare value, and by their future labours they showed how well they were entitled to that possession. Their wanderings led them from Skinningrave, on the north, to Flambrough Head, on the south; inland, the quarries in the Middle Oolites of Weaponess and Seamer, of Ayton and Malton, as well as those in the Kelloway Rocks of Hackness and Scarborough, contributed richly to their accumulating collections. While they were thus working, two literary events of very different degrees of importance occurred. One was the publication, in 1817, of Smith's "Strata identified." The other was the appearance, in 1822, of Young and Bird's "Geological survey of the Yorkshire coast." In the former work, Yorkshire fossils were but incidentally noticed; but the latter aimed at being a "full and accurate survey of the whole coast, from the Humber to the Tees." So long as its authors confined themselves to delineating the general range of the strata in the district which they surveyed, and to figuring the few fossils with which they were familiar, the publication of this work constituted a step in advance of what had hitherto been published. At the same time, a more utterly unphilosophical publication has rarely appeared. Saturated from title-page to colophon with the most consistent acceptance of the Mosaic Cosmogony, the volume is replete with speculative nonsense. The accurate, though rough figures of the more common fossils, drawn by the accomplished artist, John Bird, constituted the most useful parts of the volume.

But a very different contribution to our knowledge of the geology of the district was being quietly prepared. The late Professor Phillips, the nephew of William Smith, spent much of his time from 1817 to 1824 in assisting his uncle, to survey various parts of Eastern Yorkshire. Then becoming curator of the Museum of the Yorkshire Philosophical Society, he discovered, in their collection, further materials for a scientific study of Yorkshire geology. The sources whence he obtained additional help when preparing his "Illustrations of the Geology of Yorkshire," which appeared in 1829, is told in the preface to the third edition of that work, published in 1875. In it he says, "previous to 1824, I had, in company with the 'Father of English Geology,' my uncle, W. Smith, gathered fossils beneath the romantic cliffs which support the abbey (then almost entire) of Whitby, and the castle of Scarborough. But in that year I had the good fortune to become known to two of the most valuable of all my early friends,—Mr. William Bean and Mr. John Williamson, and to profit by their admirable collections of recent and fossil shells, Crustacea, Echinida, and Corals, dredged from the neighbouring sea, or hammered out of the neighbouring rocks." And again in his "Explanation of the plates," in the same edition (p. 321), Phillips says, "The specimens figured in the following plates were chiefly in the collections of the Yorkshire Museum, Mr. Bean, Mr. Williamson, Dr. Murray, and the author"; and the constant repetition of his name in the next ten pages, shows how well these recognitions of Mr. Williamson's labours was deserved.

The publication of the above work brings me to a period when my own personal reminiscences avail me. My father had lost two boys before they were six years of age; I fear from over teaching. Feeling terribly in his own case, the lack of education, he determined that his lads should have such educational advantages as he could afford to bestow upon them. The result was that my two brothers, one younger and the other older than myself, died of Hydrocephalus before they were six years of age, and I narrowly escaped the same fate by being transferred from school to the house of a country farmer; here the Eton Latin Grammar was exchanged for stones in a tin canister, which I had daily to rattle in order to frighten away the birds from the ripening corn; an admirable scheme for keeping me in the open air. These dangers however, passed away, and on the appearance of Phillips' work, it was my good fortune, when about 12 years of age, to make my first acquaintance with the fossils in my father's private museum.

When these fossils were collected, most of them were new, and consequently unnamed. My father naturally availed himself of Phillips' publication, to re-arrange and name the specimens in his collection according to the nomenclature of that work.

Our evenings were regularly spent in the little museum, effecting these changes. How many anathemas I secretly poured out upon the book and its author, can scarcely be told. My playmates had no such restrictions upon their freedom; they were bowling their hoops, and spinning their tops, and I longed to be with them; I felt that I should have been so, but for this obtrusive geologist and his inopportune publication. Such is the blindness of early youth! Few of those playmates did any good in the world, whilst I owe an everlasting debt of gratitude to him who thus planted tastes that have been the joy of my subsequent life. From this time onwards, our two lives and pursuits became so completely blended, that it would be almost impossible to separate the records of them.

The number of previously undescribed fossils, noticed in Phillips' book, to which the names of Bean and Williamson are attached, demonstrate the energy and success with which the two cousins explored this district prior to the year 1829. These explorations specially bore important fruit in two directions—at the southern end of Filey Bay, the blue clay known as the "Speeton" clay, crops out from below the red chalk. Phillips concluded that this clay was the equivalent of the Gault of Folkstone; but that it comprehended more than the Folkstone deposit was soon made clear. Near the base of this clay in the vale of Pickering, the two Kimmeridge clay-fossils, Ostrea deltoidea and Terebratula inconstans were found not to be uncommon. This proved to be an important geological fact.

In most parts of the world, the Cretaceous beds rest unconformably upon the Oolites; the transition from the one epoch to the other having been marked by subterranean upheavals and disturbances. But the Speeton clay was accumulated in a tranquil sea, during a period which not only embraced the age of the Portland Oolites, but also that of the Neocomian beds. Triassic and Liassic fossils are found intermingled in the strata of Hallstadt and St. Cassian; and a similar intermingling of cretaceous and Tertiary organisms occurs in the Mæstricht deposits. Both these examples indicate transitions from one geological epoch to another; so at Speeton and its neighbourhood, we pass from the Oolitic to the Cretaceous formations without any break in the continuity of a local submarine deposit of blue mud. The fossils afford the sole indications of differences of age, and ofthe transition from the Cretaceous to the Oolitic beds.

Still more important was the discovery of the celebrated plant-bed at Gristhorpe bay, now known to be a local estuarian deposit intercalated between the marine beds of the upper series of the lower Oolites.

Previous to this discovery, many fine fossil plants, chiefly Cycads, Ferns and Equiseta, had been found, in a similiar estuarian deposit, in a yet lower part of these Oolites between Whitby and Scarbrough. Amongst these plants a few of the singular objects now constituting the genus Williamsonia, had already been noticed.* But prior to the Gristhorpe discovery, our knowledge of the Oolitic flora from any part of the world was extremely scanty.

In addition to the north Yorkshire beds just referred to, a few Ferns and Cycads had been met with at Bornholm and Mamers on the continent, and at Stonesfield and Portland, in England. The Gristhorpe deposit alone added more than fifty new species to the Oolitic flora. The exact share of credit severally due to Bean and Williamson for the discovery of the Gristhorpe beds is not certain, but the probability is that it was about equal. The labour of their subsequent exploration was equally divided. These discoveries brought my father into correspondence with Mr. Adolphe Bronghiart, the distinguished author of the "Vegetaux Fossiles," who at once signified his estimate of their value by attaching the name of "Williamsonis" to four of the most striking of the newly discovered plants.†

The portion of my father's life referred to in the last few pages, was that in which he was especially brought into contact with the late Professor Phillips. I have already referred to the estimate which that distinguished geologist formed of the labours of the two cousins. And at a later page of the volume quoted (p. 193), he adds, "Since the former issues of this work, the search for fossils in the Yorkshire cliffs, which had been prosecuted with unrivalled success by Mr. Bean and Mr. Williamson, had been continued by many followers, not unworthy of such admirable leaders." And in the same page Phillips makes a further reference to their "fine and well-arranged cabinets."

---

* Young & Bird, plate 2, fig. 6, and plate 3, fig. 7.

† Prodrome d'une Histoire des Végétaux Fossils, pp. 50, 57, 83 & 95, 1828.

About the year 1826 our home life was diversified by a not unimportant event. William Smith, "the father of English Geology," had long been interested in Scarborough and its vicinity, and in the year referred to, he and his eccentric wife took up their abode in our house, where they remained for two years. I need scarcely add that the value, to me, of this close association with the creator of modern geology, was great. Just beginning to join my father in his excursions, and to take an interest in their results, the constant presence of a man like Smith was not calculated to diminish that interest.

But a still more important event was at hand. A Literary and Philosophical Society was established in Scarborough, and a museum erected in 1829. To this Society my father sold his fine collection for £75; returning one third of the money as a contributionto the Society's funds. At the same time he accepted the office of "Keeper" of the museum, with the extravagant remuneration of £30 per annum. In their third annual report for 1830-31, I find the not inappropriate reference to "the salary of that very inadequately paid, but valuable servant, the Keeper."

This appointment gave a new turn to my father's life. With the exception of continuing to superintend the gardens and vineries of a Mr. Frank Henderson, professional gardening was now abandoned. The Society of whose museum he took charge, had no collections of its own, save a few fossils and minerals of small value that had been left by Thomas Hinderwell, the historian of Scarborough. My father's fossils, recent shells and minerals, constituted the principal nucleus around which future accumulations had to gather. Of birds and animals there were none; but an arrangement was made with the late Mr. Arthur Strickland, who then resided near Burlington, and who had made a respectable collection of British birds. The whole of his cases were transferred, for a brief period, to the new museum; meanwhile, every nerve was strained to form collections of our own. At that period the art of taxidermy was in a low state. The only man in the kingdom who had any reputation for skill as a stuffer of birds, was Mr. Timothy Harrop, then the curator of the museum of the Natural History Society, at Manchester. My father's first work was to proceed to Manchester, where he spent some weeks in receiving practical instructions from Harrop, in skinning and mounting birds and animals. The winter succeeding this journey was a very severe one, and rare birds of various kinds were unusally abundant. The keepers of Sir John Johnstone, Sir Charles Legard, and other neighbouring land-holders, received instructions to give all assistance in their power in making additions to the Ornithological collection; hence it not unfrequently happened that as many as eight or ten birds had to be skinned in a day. The greater proportion of this skinning fell to my lot, my father completing the more difficult work of stuffing and mounting the objects. When spring returned, and the summer birds of passage began to surround us, much of our time was spent gun in hand, the result being, that in about a year, when Mr. Strickland's birds were removed, a very respectable collection was ready to take their place.

The next gap to be supplied was an Entomological one. No collection of insects then existed in Scarborough, but every opportunity was embraced of scouring the country, for miles around, in search of tiny game. Every evening, when the weather permitted, found us, net in hand, at certain favourable localities collecting the night-flying Lepidoptera. The carcases of the birds we had skinned, were deposited in the surrounding plantations, as traps for the Necrophagous Coleoptera, which traps were inspected daily; and at the same time a series of breeding cages were established, in which Larvæ were fed and reared, until they matured in perfect forms of Lepidopterous life. Beating the woods for larvæ, with a huge sheet spread under every tempting branch of Oak, Hawthorn, or Birch ransacking the Poplar plantations for the caterpillars of the

Sphingidæ; the grassy hedge rows for those of the Eggers, Drinkers and Tiger Moths; and the heathy moors for such insects as the Emperors, Ruby and Wood-tigers, became part of our regular work. It was a bright and a joyous time.

Our only Entomological triumph of any importance, was the discovery of a rich locality at the foot of the north cliff at Scarbrough, for the rare Carabid Beetle, Nebria livida. Previous to this discovery, but two or three individuals of this elegant insect had been found in Britain, which fact we learnt from one of the earliest numbers of Curtis's English Entomology. Under the impression that we had seen something like Curtis's figure, we turned to our cabinet and there we found a solitary example of the rare insect, but could not recall where we had captured it. Two or three years later, hunting for fossils amongst the fragments of Cornbrash that had fallen from the cliff overhead, we stumbled upon a second specimen, and then remembered that we had obtained the first from the same spot. We subsequently supplied many of the leading Coleopterists of England from this, long the only known, locality for the beetle.

Throughout the period during which my father held the keepership of the museum, he was ever ready to aid such visitors to Scarborough as were interested in pursuits kindred to his own. Charles Waterton, Professor Agassiz, and numerous other eminent naturalists were amongst his personal friends. But his delight was the greatest, when he was able to help any young aspirants after scientific knowledge. I am indebted to my distinguished friend Professor Flower, LL.D., now the lead of the Natural History Departments of the British Museum in Cromwell Road, for the following sketch of his youthful experience in this direction:—

British Musem (Natural History),
Cromwell Road,
South Kensington, S.W.,
May 8th, 1884.

Dear Professor Williamson,

It was in the summer as near as I can recollect, of the year 1840, when I was between nine or ten years old, that I spent some months at Scarbrough. Already the taste which has determined my career in life, had developed itself; the museum was to me the most attractive of the many interests of the place, and I very soon made friends with its curator, your father. I was even then an ardent collector, and of course I brought the fossils which I found in the cliffs, or the butterflies caught in the neighbouring fields and lanes to compare with those in the museum, and get them named. Once, upon a day never to be forgotten, I picked up a dead Guillemot upon the beach. It was in perfect plumage, and I carried it off to the museum, where, in his work-room in the basement, your father skinned and stuffed it before my wondering and admiring eyes. This was my first lesson in taxidermy an art over which I afterwards wasted many a day and night, with great enjoyment if perhaps little profit, it has, however, given me the power of appreciating good work of the kind in others, and of being made miserable by the far more frequent sight of bad. I well remember, as if it were yesterday, the delight with which I followed, and the kindness with which Mr. Williamson explained to me the various stages of the process, and as one of those things, which for some inexplicable cause stand out clearly in the memory amid a surrounding haze. I have still a most vivid presentment of the string with sharp iron hook at end, which hung from a beam in the ceiling, over the table, and to which he fixed up the body while peeling off the skin from the breast and neck of the bird. I have never visited Scarborough since, nor did I ever see your father again; but I owe much to him for the kindly encouragement he gave to the boy who went to him with no introduction but his love for the objects among which the good old man lived and worked.

Believe me,

Yours very faithfully,

W. H. FLOWER.

It will readily be seen that Mr. Williamson could not live upon the small stipend he received as keeper of the museum. On his return from the north, my mother resumed her old occupation as a milliner and dressmaker, and aided by a considerable staff of young people, she brought a substantial addition to the family finances.

A few hundreds of pounds were left them on the death of an old friend; this they invested in a lodging-house of the usual watering-place type, which made some further addition to their income. This investment was exchanged for a similar, but more important one at a later date. When in the service of the Earl of Mulgrave, Mr. Williamson had saved some money wherewith he purchased a small share in a ship, employed by the government in the transport service, during the Peninsular war. This investment unfortunately proved a very lucrative one, but bore fruit of another kind at a later day. He also purchased a small plot of land outside the town, on which he ultimately built for himself a snug little cottage. On the construction of the York and Scarborough Railway, the Railway Company required this land, paying him £1150 for it. The old mania for dabbling in shipping unfortunately returned upon him, but the times were unfavourable. Steamers were beginning to supplant small sailing vessels, and the result was the loss of all the money. Throughout life an earnest Liberal, he took an active interest in the politics of the borough, steadily supporting the late Sir John V. B. Johnstone, of Hackness, first as candidate for Yorkshire on the elevation of Brougham to the woolsack, and subsequently as one of the members for Scarborough. He also was much interested in the foundation of the British Association for the advancement of science, having been one of the small gathering which met at York under the presidency of Earl Fitzwilliam on September 27th, 1831; at that meeting he exhibited a series of the fossil Crustacea which he had discovered in the rocks of eastern Yorkshire. He continued to display the same activity and energy that had characterised his earlier years until age began to show some of its natural results; in January, 1853, at the age of 69, he resigned the keepership of the museum of which he had so long had the charge. He had become too old to have his movements controlled by any external authority however kindly exercised.

But though thus freeing himself from all official work, there yet remained in him an amazing store of energy, which found vent in several directions. At the time when he resided in his cottage, near Falsgrave, to which reference has been made, a Floral and

Horticultural Society was founded at Scarborough, of which he became almost the mainspring. Not only was he one of its most energetic officers, but also one of the largest exhibitors of greenhouse plants at its annual shows. A small greenhouse and a considerable range of frames, enabled him to promote horticultural pursuits by example as well as by official precepts. He persevered enthusiastically in plant culture, not only long after the breaking up of the above society, but to the end of his prolonged life. His geraniums, fuschias, and calceolarias continued to delight him to the end. His energy in working with spade and hoe in the hard clayey soil of his garden, would have put to shame the indolence of men of half his years. Still retaining his love for his gun, he on one occasion gave an illustration of his physical powers. When between eighty and ninety years of age, he accompanied several friends on an annual rook-shooting visit to Hackness. He walked thither in the morning, a distance of six miles, and spent the entire day wandering up and down the steep hill-side where the rookery is situated. A carriage had been provided to carry the more tired men back to Scarborough, but he declined, with scorn, to avail himself of its aid. Shouldering his gun, he returned home along with his younger pedestrian companions.

Another of his pursuits continued to be a favourite one with him to a late period. Always a disciple of Isaac Walton, in his later years he contented himself with sea-fishing, his favourite spot being the end of the new pier erected in the north bay at Scarborough. His implement was usually a string of hooks at the end of a lengthy line. When fishing, his manly form attracted the attention of all who came near. With his line carefully coiled at his feet, and himself standing erect as a young pine tree, he whirled the weighted end of his line high above his head, until having given to it the needful impetus, he flung it far out to sea; whiling away hour after hour in this amusement, as if fatigue was a thing unknown. He only returned home with his basket full of fish, to exchange one activity for another. The fishing line was replaced by the cue. The evening was commonly devoted to the bagatelle-board; and night found him enjoying the sleep of the labouring man.

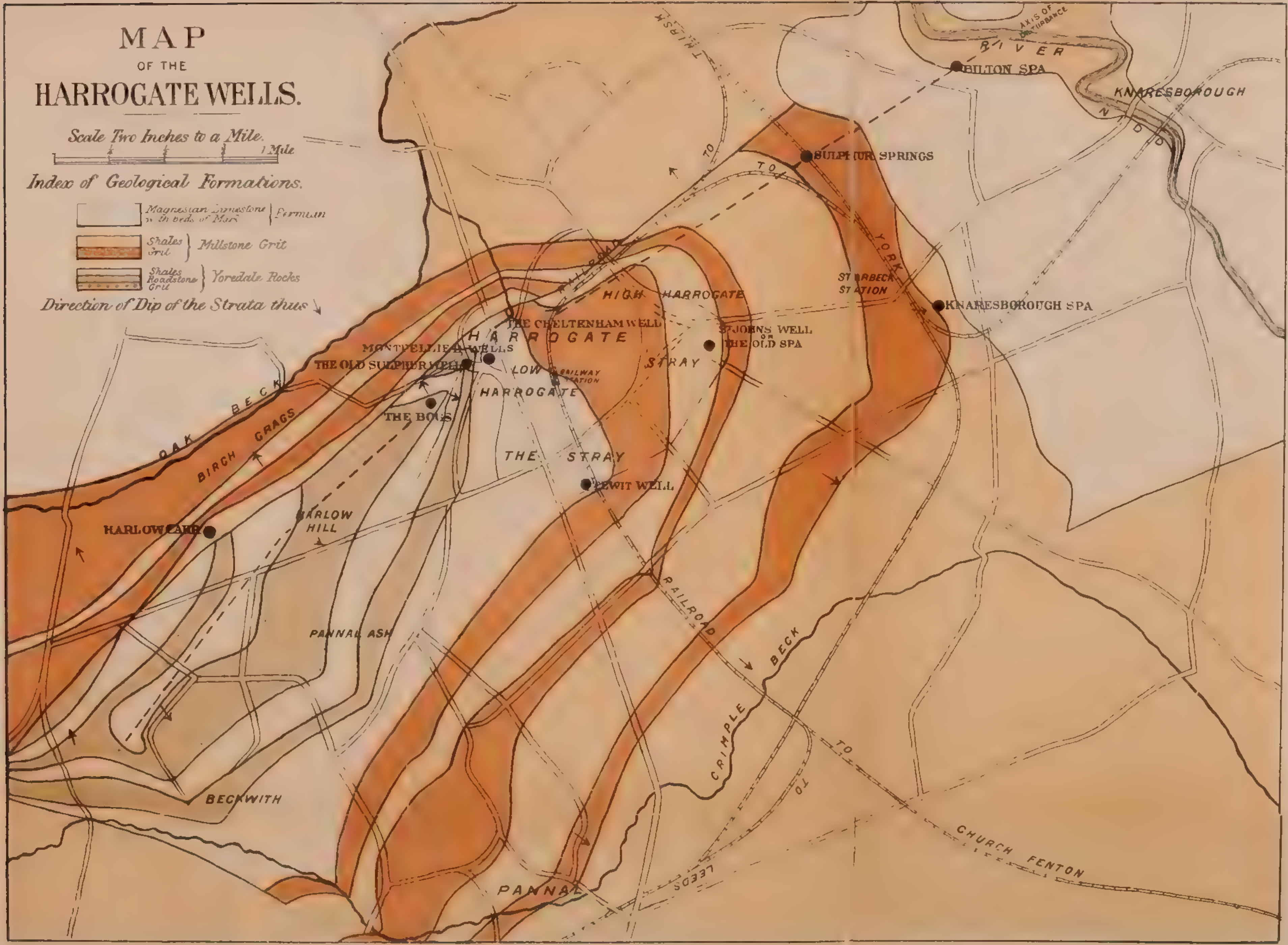
During his entire life he was a voraceous reader, especially of travels; his one eye never seemed to tire of dwelling upon their pages.* When increasing infirmities diminished his activity for out-door occupations, books never failed to interest him. During his later years, he suffered from severe attacks of bronchitis, but the end was brought about through a general failure of the vital powers, rather than from any specific disease. He died on July 15th, 1877.

ON THE MINERAL WELLS AT HARROGATE. BY RICHARD CARTER, C.E., F.G.S.

The Council of the Society having done me the great honour of appointing me to preside on the present occasion, I embrace the opportunity with more than ordinary pleasure and gratification of bidding hearty welcome to the Society on this, its first general meeting at Harrogate. When I reflect upon the lengthened period during which I have been upon the roll of its members, and the number of years I have had the honour of being upon the Council, it excites a feeling akin to reproach, that the Society has not sooner been prompted to assemble here, in order that the members should have enjoyed an opportunity of investigating on the spot, those natural peculiarities and hygienic resources for which Harrogate has so long been famous. "Better late than never," and I rejoice exceedingly in the prospect which this meeting affords of adding something to our knowledge of the geological structure of the district, and the manner in which that structure bears upon the many and varied mineral springs which have given to Harrogate a very prominent reputation, and which, in connection with the remarkable salubrity of its climate and centrality of its geographical position, would seem to entitle it to rank amongst the most favoured and important watering places in Europe. The general plateau of Harrogate, elevated about 400 feet, and on the westerly side at Harlow Hill to 600 feet above the level of the sea, has somewhere (and, perhaps, not inaptly) been said to present the highest table-land in Europe. This elevation affords very singularly commanding views of the surrounding country, and from the position of Harlow Moor, especially, which through the generosity of the Earl of Harewood, is now being laid out by the Municipal authorities in most attractive walks and drives, an extended landscape may be enjoyed, which in grandeur and interest is rarely equalled. The last twenty years—since the facilities of access were so much improved—have witnessed a vast increase in Harrogate as a place of residence and health-resort. The population, which in 1861 was 5,000 to 6,000 is now increased to about 11,000, and it is estimated that about 15,000 visitors are added to that number in the height of the season. On the first of February of the present year, the Royal Charter was granted, and Harrogate now ranks amongst the Incorporated Boroughs of the United Kingdom. Thus much for its topography. I must now return for a few brief and general observations on the physical aspects of the district, which are intended to form the more immediate theme of consideration for our present assembly. It is now about half a century since geological theory was brought to bear upon Harrogate, and the probable origin of its singularly diversified and highly esteemed medicinal springs. Legal controversy had arisen, directly bearing on this point; and it is not without a special degree of interest and gratification that I can appeal to that opportunity, of being an eye-witness of the presence and researches in Harrogate of the venerated William Smith, the accepted father of English geological science,—of his accomplished nephew, the late Professor Phillips, and a phalanx of eminent geologists and chemists of that day, whose practical knowledge and judgment were exercised for the settlement of the intricate and not less important questions which were at the moment in dispute. The proceedings to which I refer will form an important feature in the history of Harrogate, and I trust they will constitute a beacon in the future, as they have done in the past, for the purpose of inspiring protection and conservation to the invaluable treasury which Harrogate possesses in her mineral springs, not only as a basis of her own material welfare and prosperity, but also as the heritage she enjoys alike for our fellow-countrymen generally, and for humanity at large. I have hinted that as far back as the year 1836, legal proceedings took place, in which the right to injure or endanger the existence of our mineral springs was challenged and successfully controverted. In the Act of Parliament for the Improvement of Harrogate, which passed some 5 or 6 years afterwards, all excavations of the surface were prohibited within 300 yards of the Old Sulphur Well; and this stipulation has since been increased and intensified by Provisional Order, so that practically any unauthorised digging or excavation within 600 yards of the Old Well is now prohibited, and may be visited by severe penalties. I have felt it important to be thus particular in noting the protective conditions referred to, inasmuch as their existence is not at all times a sufficient guarantee for their due and proper observance. Enormous interests, both public and private, are dependent upon a vigilant and proper exercise of the precautionary authority which the legislature has created; and I only regret that past experience does not enable me to pass on from this topic without a sentiment of wavering confidence in local authority, and a lively hope that by bringing it thus prominently under notice of our society to-day, its members may feel themselves charged with a special zeal and interest in the preservation of the springs of Harrogate, which, as I have already intimated, are not only of local, but of universal value and importance. It is most gratifying to me, and I am sure will be equally interesting to this meeting, that the mineral springs of Harrogate will be discussed in a paper about to be read to you by Mr. C. Fox Strangways, than whom no more competent scientific authority could have favoured us by his presence and efforts. Mr. Strangways having been responsibly charged by the Ordinance Department with the geological survey of this district, has necesssarily dedicated to it an amount of research and observation, far beyond what the most zealous amateur could at all aspire to; and I think we may congratulate ourselves notwithstanding all I have previously said of Father Smith, and others, that the local geology of Harrogate will be illustrated to us, by the most advanced knowledge of the day and period in which we live. It would be ungenerous, as I am sure it is unnecessary, for me to occupy your time further upon the geological or chemical features which will be at once brought under your notice. I may say, however, that I accept generally the structural description which has been given of the district by nearly all the practical geologists who have written or reported thereon. That we owe the peculiar aspects of our naturally gifted position to the great axial development running nearly east and west through the central basin of Harrogate, appears to me beyond the reach of question or doubt. It is remarkable, however, to what an extraordinary height the lower strata have been pushed up by the great anticlinal here referred to, as compared with the rocks (and their altitudes above the sea level), by which Harrogate is surrounded. I take the altitude of the Old Sulphur Well at say 340 feet above the sea; and here we have the spring exuding from stratification of a transitional order, not very remotely identified with the great and massive formation of the carboniferous limestone. It is not, however, by the immediately local contrasts that we can adequately judge of the grand geological problems at issue. Let us assume that the zone we now occupy in its undisturbed position, covered not only by the superimposed mass of the millstone grit, but also by the overlying coal bearing strata, which still flanks us at Horsforth on the south, and, although at a much greater distance by equally obvious relationships on the north. We have, then, but a slight effort of imagination to picture the time when the coal fields of Yorkshire and Durham were one continuous and united, or unbroken field of mineral wealth. This continuity has been broken, and some idea may perhaps be formed of the important part which the Harrogate Anticlinal has played in bringing about this mighty revolution, if we reflect upon the fact that strata exposed in the basin of Low Harrogate, if sought for at Horsforth, only some eight or ten miles away, would be found at a depth of 1,200 or 1,500 feet below the present surface at that place. In the very able memoir on the Geology of the country north and east of Harrogate, from the pen of Mr. Strangways, it is suggested that "the Anticlinal appears to die out eastward from Harrogate, and there is no great anticlinal of Carboniferous rocks below the Permian and Trias in this part of the country." To this conclusion my speculations had led me some years ago; and arguing from somewhat different premises, I ventured to suggest that along a line sufficiently eastward from the westerly margin of the Permian stratification, the coal strata might be yet intact, although now overlaid, and perhaps buried at an unapproachable depth by the later and unconformable deposits of the Permian and Trias systems. This huge upheaving force is further apparent in the gradual exposure of the lowest rocks of the Millstone Grit and Yoredale series, and the vast extent to which they have been wasted by the forces of denudation along the line of axial elevation, and noting further, the remarkable coincidence of the Magnesian Limestone deposited as we find it upon the Yoredale shales on the Bilton side of Harrogate, we are led by such combination of physical testimony, to sympathise to some extent with the idea suggested by our local and much valued and esteemed authority, Mr. Grainge, that the traces of an agency akin to volcanic force must have been employed in bringing out the striking and confessedly unique features which Harrogate presents. Hastening to the conclusion of my remarks, I would add a word or two on the particular beds which characterise the basin of Low Harrogate, and are confessedly identified with the origin and sources of our Mineral Springs. These beds, as Mr. Strangways has pointed out in his very valuable memoir, consist of alternating shales and sandstones—and amongst the latter, the calcarious and fossiliferous grit of Harper's quarry and Cornwall-house, called by Mr. Strangway's the "Harrogate Roadstone" may be accepted as a distinguished member, of much importance both geologically and economically. The shales above and below this stratum are very dark in colour, and of great thickness. It is not easy to measure or estimate them in this respect, as the entire locality displays such evidence of general disturbance, and the effects of greatest denudation have done little more than expose the surface of the lower shales. Mr. Strangways has recorded in his memoir the result of a boring, near Starbeck, carried to the depth of 437 feet, which seems to establish my proposition; the black shales towards the bottom of this boring, alternating with bands of stone, being quoted 117 feet thick in the upper, and about 137 feet thick in the lower portion. Taking the lower quotation, it represents strong open black shale, 5ft. 8$\frac{1}{2}$in.; black shale and mixture of sulphur, 131ft. 5in. The situation of this boring is about 1$\frac{3}{4}$ miles eastward from the Old Sulphur Well, and as regards surface level, about 15 or 20 feet lower. These conditions may not tend to facilitate very clearly the identity of stratification at the two points. Having regard, however, to all the circumstances of disturbed stratification, and the probabilities of a rapid dip to the eastward, I cannot but consider the correspondence of value, which the Bore Hole discloses. Excavations in different parts of the basin of Low Harrogate, have testified to the general prevalence of this black shale, and of the distinctly mineral character of the waters which permeate its mass. The general testimony of scientific authority, so far back as 1836, concurred in the probability of axes of disturbance following the course of each of the minor valleys which focus in what is now known as Cheltenham Square; and above and below this conjunction the black shale has been found by frequent excavations where the depth has been carried beyond the thickness of diluvial clay or gravel which exists at the surface. In the excavation for the new culvert through the Spa Concert Grounds a year ago, the shale was met with about the east side of the skating rink, and pursued as far as the culvert, extended to Ripon road. At the Victoria Baths, and quite up to the public road which passes the Town Hall, considerable excavations have been made in years gone by, penetrating the black shale to a depth of perhaps 10 or 12 feet. In these operations additions were made at this place to the number and importance of the sulphur springs which now supply those baths. In like manner the shale has been attested between the baths and the Old Sulphur springs. These facts combine to show, I think, an exposure in the basin of Low Harrogate of the deeply seated shale, which is in direct relation to, and in fact forms part of the vast mass of Yoredale shales and bands of interstratified rock, which have their developement in the extensive and elevated tract of country lying to the west, and between Harrogate on the east and the valley of the Washburn on the west. At this point I leave the subject, and the deeply interesting details with which it is invested, to be more ably handled by Mr. Strangways, Dr. Oliver,

---

* He had lost the use of his left eye from small pox in his early youth.


MAP
OF THE
HARROGATE WELLS.
Scale Two Inches to a Mile.
1 Mile
Index of Geological Formations.
Magnesian Limestone with beds of Marl
Permian
Shales
Grit
Millstone Grit
Shales
Roadstone
Grit
Yoredale Rocks
Direction of Dip of the Strata thus
AXIS OF DISTURBANCE
RIVER
NIDD
BILTON SPA
KNARESBOROUGH
TO THIRSK
TO YORK
SULPHUR SPRINGS
STARBECK STATION
KNARESBOROUGH SPA
HIGH HARROGATE
RAILROAD
THE CHELTENHAM WELL
HARROGATE
ST JOHNS WELL OR THE OLD SPA
STRAY
MONTPELLIER WELLS
THE OLD SULPHUR WELL
LOW HARROGATE
RAILWAY STATION
THE BOGS
OAK BECK
BIRCH CRAGS
THE STRAY
TEWIT WELL
HARLOW CARR
HARLOW HILL
PANNAL ASH
RAILROAD
CRIMPLE BECK
TO CHURCH FENTON
TO LEEDS
BECKWITH
PANNAL

and Mr. Davis, apologising if my remarks have intruded upon the aspect in which they are about to present them for our further and more edifying consideration.

THE HARROGATE WELLS, OR THE MINERAL WATERS OF HARROGATE GEOLOGICALLY CONSIDERED. BY C. FOX STRANGWAYS, F.G.S., ETC., OF H.M. GEOLOGICAL SURVEY.

Until about one hundred and fifty years ago Harrogate was almost unknown, although some of the principal mineral waters had been discovered nearly one hundred years previously. Medical accounts of the waters appeared as early as the beginning of the seventeenth century, but it was some time before the place attained much celebrity. Towards the close of the sixteenth century (the exact date seems to be rather uncertain, some authorities giving it as 1570, and others 1576, while others again place it as late as 1596), Sir Wm. Slingsby accidentally discovered the Tewit spring, one of the principal chalybeate waters of Harrogate, and one that has been largely used ever since.

The next well to be discovered, was the Sweet Spa or St. John's Well, which was found about the year 1601. In 1626 Edmund Dean first drew public attention to the Old Sulphur Well, the most famous of all the Harrogate waters.

In 1783 the Saline spring in the grounds of the Crescent Hotel was discovered; and during the present century many additions have been made, from time to time, to the number of mineral springs.

In 1819 we have the discovery of the Cheltenham spring, then known as "Oddy's Saline"; and 1822, that of the Montpellier Sulphur Well; and in 1840, the springs at Harlow Carr.

Thus from time to time as the country became more opened out and cultivated, fresh springs were discovered, and their peculiarities examined; until within the last few years the whole country has become so thoroughly well-known, that there is not a single spot which has not been explored.

Now let us turn to the physical and general geological structure of the neighbourhood. And in order that you may thoroughly understand my views, it will be necessary to include in this description, the whole of the western part of Yorkshire lying between the Pennine Chain and Harrogate.

This district includes the mountainous region to the west of the Vale of York, in which the principal rivers of the county have their rise; it is the water gathering area of this part of England, the average rainfall over the higher parts of this region being from 30 to 100 inches in the year; and it is my intention to show presently that it is from this district that the Harrogate springs derive their supply.

The district under consideration, is bounded on the west by the axis of the range of hills which is popularly called "the back-bone of England." This range, of which Great Whernside, Pennegent, Widdale Fell, the Great Shunner, and the Nine Standards are some of the highest points, rises to heights of between two and three thousand feet.

The rocks of which this district is mainly composed, are the lower members of the carboniferous series which, for convenience, we divide into the separate groups, Millstone Grit, Yoredale rocks, and Mountain or Scar Limestone; and these three principal divisions are further sub-divided into their separate beds of sandstone, shale, limestone, or chert, some of which have very distinctive characters which they retain throughout large areas.

In the present instance, however, it will not be necessary to trace and describe the whole of these; it will be sufficient for our present purpose, to take those only which occur in the immediate vicinity of Harrogate. These are the lower beds of the Millstone Grit, and the upper portion of the Yoredale rocks.

The Millstone Grit of this district is, for the most part, a series of some half-dozen beds of coarse massive grits, separated from each other by thick beds of shale. A very good section of these rocks is exposed along the railway cutting from Harrogate to the south; but the best idea of the nature of the grits themselves, is obtained from Plumpton rocks, Birk Crag, and Almes Cliff rocks. It is these rocks which, stretching over the moorlands to the west, form some of the grandest and wildest of the Yorkshire scenery.

The Yoredale rocks at Harrogate, consist in the upper part of dark blue shales, these being succeeded by thin bands of earthy limestone and chert containing Encrinites. This cherty limestone is the so-called roadstone of Harrogate; its exact position in the geological scale is somewhat doubtful, Prof. Phillips considering it to be the equivalent of the main or twelve fathom limestone at the top of the Yoredale series.* It is a hard siliceous rock with a conchoidal and hackly fracture, but it is very frequently much decomposed, having all the calcareous portion dissolved out, when it resembles pumice-stone in texture. It is extensively quarried in the neighbourhood for mending roads. These cherty beds rest on dark blue shales containing sulphur, iron, and probably several other chemical substances; and below these again, we have a thin rubbly sandstone also containing sulphur and iron, resting on other beds of shale, which are the lowest strata visible in the neighbourhood.

The precise equivalents of these measures to the west, are rendered somewhat doubtful by the thinning out of one or more of the beds in the country to the west of Harrogate; for if we examine the country west of the Millstone Grit area, where we should expect to find the same measures cropping up, we can discover no rocks which exactly correspond to those at Harrogate. The reason of this is, either that the Yoredale measures gradually become thinner until they finally disappear in their passage to the west, or that they are so altered in their general composition, as to be no longer recognisable as the same beds. When such changes as these take place in an isolated area like Harrogate, it is extremely difficult to identify the beds, or to say exactly to what part of a formation they belong. In this case, the only clue we have to their correlation with the strata of a known area, is the lithological character of the rocks, and even this is not always to be depended upon. But we shall not be far wrong in considering these beds at Harrogate a portion of the Yoredale series, for it is evident they lie below the Millstone Grit, while at the same time they must be above the Scar Limestone, unless that formation had thinned out, which is not at all likely in so short a distance.

---

* *Quart. Journ. Geol. Soc.*, Vol. XXI., p. 234.

The strata which occupy the district to the west of Harrogate and south of Settle, are thrown into a series of nearly parallel anticlinal and synclinal folds, ranging E.N.E. or N.E., of which the most remarkable are those in the neighbourhood of Bolland and Clitheroe, by which the Scar Limestone and the beds of the Yoredale series are frequently brought to the surface, and extend in long lines across the country to Skipton and Appletreewick; from thence their direction is nearly east towards Harrogate and Ripon. Along these lines the higher and middle members of the Millstone Grit rocks are wanting, and we only have just the lowest beds of Millstone Grit enclosing elliptical patches of Yoredale rocks.

If it were not for these anticlinals the Millstone Grit might be separated from the Yoredale rocks below, by a nearly north and and south line ranging along the western side of Great Whernside, Rylstone Fell, and Skipton; then in a general way with the exception of some of the higher hills which are capped with Millstone Grit, all the country lying west of this line would be composed of Yoredale rocks, while that to the east would have the various members of the Millstone Grit; as it is, this regularity is broken by the disturbances mentioned above, so that the base line of the Grit retreats considerably further to the east in the neighbourhood of Greenhow and Skipton. It is with the southern of these two lines of disturbances that we have chiefly to deal.

The anticlinal upon which Harrogate stands is a continuation of that at Skipton, although its direction in the neighbourhood of Harrogate is about N.E. and not nearly E. as this would lead us to infer. Its course across the moors from Bolton Abbey to Harrogate is well marked on the high ground about Beamsley Beacon, but from thence eastwards, it is not so easily traceable till we get within a mile or two of Harrogate, when its general outline again becomes very distinct.

At Harrogate the general geological structure is rendered very apparent by the massive grits at Pannal and Birk Crag, where we have the same bed of grit striking in a north east direction on either side of the anticlinal, and giving at a glance, the key to the main geological features of the neighbourhood.

The axis of this disturbance is well shown in the town of Low Harrogate, by the quarries which have been opened for roadstone on either side of the "Bogs"—here the impure limestone of the Yoredale series may be seen dipping respectively N.W. and S.E. at high angles, on either side of this little valley; the same thing occurs near Beckwith Shaw to the S.W. of Harrogate. From these two positions the general run of the axis of disturbances may be easily gathered.

The exact base of the Millstone Grit is not so easily traceable in all cases, and can only be followed by very close inspection and consideration of the country. On the southern side of the anticlinal its general course is from the south of Pannal Ash, across the Stray to High Harrogate; to the north of the town its outcrop being obscured by faults is not so well marked, the junction with the underlying Yoredale measures ranging along a N.E. line from near Shaw Green, to the north of Harlow Hill and Low Harrogate. Between these two lines is an area of about three square miles of Yoredale Measures, upon which the town of Low Harrogate is situated.

The highest point of this area is Harlow Hill, 600 feet above the sea, and it is here that the greatest amount of disturbances appears to have taken place. The sandstone which caps this hill is one of the lowest beds of the district, and as we have already seen before, underlies the roadstone of Harrogate and Beckwith Shaw, towards both of which places it has a considerable dip. About half-a-mile on either side of this hill occur some of the principal Sulpher Springs of the neighbourhood; to the more particular discussion of which we will now turn; and glance at their principal chemical constituents.

I do not propose in this paper to enter into their medical qualities—as this has been already ably discussed by several eminent medical men—my object is to show the principal constituents of the various groups into which the waters may be divided, and to point out how one group differs from another. In the tables I have noted the *characteristic* constituents of the principal springs, and it is with these only we need trouble ourselves; the other constituents of the water occur only in small quantities, they are probably due to local causes and do not effect the general principals with which we have now to deal. For this reason the tables are not the exact analysis of any particular spring, but show the maximum and minimum constituents of the different groups, so that we may see at a glance, the greatest and least amount of the several ingredients conveyed by these waters.

TABLE I.*

CONSTITUENTS IN THE GALLON OF WATER.

	CLASS I.		CLASS II.		CLASS III.		CLASS IV.		
	Strong Sulphur.		Mild Sulphur.		Saline Chalybeate.		Pure Chalybeate.		
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	
Chloride of Sodium ...	893.670	369.014	232.413	121.798	656.838	158.840	1.543	0.280	GRAINS.
Chloride of Calcium ...	81.735	43.635			159.278	51.629			
Chloride of Potassium ...	64.701	5.750	24.970	3.975	27.410	11.383	1.323		
Chloride of Magnesium	55.693	11.595	17.140	0.336	35.635	34.047			
Chloride of Barium ...	6.566								
Sulphide of Sodium ...	15.479	5.215	3.398	0.301					
Carbonate of Lime ...	29.768	12.365	20.457	6.960	7.604		2.264	1.435	
Carbonate of Magnesia ...	5.953		10.310	3.251	41.797		3.039	2.667	
Carbonate of Iron ..	1.060	Trace.	Trace.	Trace.	4.627	2.790	1.358	0.609	
Carbonate of Soda ...			5.133				1.338		
Carbonate of Potash ...			12.207						
Silica ...	1.840	0.246	1.753	0.165	1.450	0.947	1.041	Trace.	
Carbonic Acid	22.03	9.54	14.28	9.26	24.17	19.50	14.95	11.85	CUBIC INCHES.
Carburetted Hydrogen ...	5.84	0.15	5.28	0.90	5.00	2.40	0.15		
Sulphuretted Hydrogen ..	5.31		Trace.						
Nitrogen ...	19.78	2.91	7.67	4.21	6.48	1.02	6.35	5.53	
Oxygen ...	0.48		1.81		0.51		0.67	0.40	

---

* This table is compiled from the analysis given by Hoffmann, in 1854; corrected in some cases by those of later date.

TABLE II.

PERCENTAGE OF FREE GASES.

	Old Sulphur Well.	Hospital strong Sulphur Spring.
Carbonic Acid	3.28	0.09
Carburetted Hydrogen ...	40.00	
Sulphuretted Hydrogen ...	Trace.	Trace.
Oxygen		
Nitrogen	56.72	99.91

TABLE III.

CHARACTERISTIC CONSTITUENTS OF THE SEVERAL GROUPS.

	Rich in	Less rich in
CLASS I.	Chlorides Sulphides Free Gases	
CLASS II.		Chlorides Sulphides Free Gases Carbonates
CLASS III.	Chlorides Carbonates	
CLASS IV.		Carbonates of Iron Carbonates of Magnesia

There are six characteristic gaseous principles in the Harrogate waters. These, as we see from the tables, are Carbonic Acid, Carburetted Hydrogen, Sulphuretted Hydrogen, Chlorine, Nitrogen, and Oxygen. These gases occur in three distinct forms in the several waters: in a free state when they rise from the water in bubbles; simply dissolved in the water when they can be expelled by ebulition in vacuo; and in combination with various salts, when a chemical decomposition is necessary to detect them.

Now the first thing for us to consider in the chemical examination of these waters is, in which of these forms do the various constituents exist in the water before it becomes acted on and decomposed by exposure to the air. We must draw our conclusions from the water as it leaves the various strata to which it owes its peculiar properties, and not from a long list of ingredients which are only the result of the chemical decomposition of our analytical investigation in the laboratory, or have taken place from contact with the air. It does not seem, as yet, to have been very clearly made out in what state the sulphuretted hydrogen exists in the Sulphur water of Harrogate. Is it in a free state merely dissolved in the water, water absorbing nearly three times its bulk of this gas: or, is it in a state of combination (as hydrosulphuric acid) with the bases of soda, lime, and magnesia?

Dr. Bennett * considered that there was no free sulphurretted hydrogen in any of the waters, but his method of analysis seems to be considered fallacious by modern chemists, and Professor Thorpe states that at least a portion of this gas does exist in an uncombined state.† Dr. Oliver also states that the sulphuretted hydrogen, "though undoubtedly present, represents but a portion, and, that generally, a small portion of the total sulphur charge, and is subsidiary to—possibly derived from—an alkaline sulphide."‡ Chlorine enters largely into combination with Soda, Lime, Potash, and Magnesia, and in this form appears to be one of the principal gases in all the waters

---

* *Observations on the Sulphureous Springs of Harrogate*, p. 10, by William Bennett, M.D., 1843.

† *A Contribution to the History of the Old Sulphur Well, Harrogate*, by T. E. Thorpe, Ph.D., F.R.S., *Philosophical Magazine*, July, 1876.

‡ *The Harrogate Waters*, by George Oliver, M.D., 1881.

except the Pure Chalybeate.

The Oxygen and Carbonic Acid are also probably in a state of combination principally with Lime and Magnesia, while the Nitrogen and Carburetted Hydrogen appear to be in entirely a free state. Of those gases in a free state the Strong Sulphur Water gives by far the largest result; for if we turn to Professor Hoffmann's analysis we find that the gas rising from the surface of the Hospital Strong Sulphur Spring contains no less than 99·91 per cent. of Nitrogen with a very small per centage of Carbonic Acid; and if we examine all the stronger sulphur wells we shall find that the percentage of this gas in a free state is always very large: of the other gases in a free state the Carburetted Hydrogen appears to be the one which is most abundant, the Old Sulphur Well containing, according to Hoffmann, as much as 40 per cent. of this gas. Of the gases which are dissolved in the water itself, and which are only expelled by ebulition in vacuo are Carbonic Acid with smaller proportions of Carburetted and Sulphuretted Hydrogen.

And lastly the most important of the gases which are in chemical combination with various bases are Sulphuretted Hydrogen, Chlorine, and Carbonic Acid, which latter may be taken as including the greater part of the oxygen mentioned above. The non-gaseous constituents of the water are chiefly salts of Soda, Lime, Magnesia, and Potash.

Professor Hoffmann in his analyses of these waters has divided them into four principal groups:

Class I.—The Strong Sulphur Water.
Class II.—The Mild Sulphur Water.
Class III.—The Saline Chalybeates.
Class IV.—The Pure Chalybeates.

and this seems to me to be the best mode of classing them with reference to their sources.

The principal springs of the Strong Sulphur Water are the old Sulphur Well, one of the Wells in the Montpellier Gardens, and the Hospital Strong Sulphur Well. These are all characterized by the large amount of Chloride and Sulphide of Sodium they contain, as well as by the great bulk of their gaseous constituents, especially

Nitrogen, Carburetted and Sulphuretted Hydrogen and Carbonic Acid.

The Mild Sulphur, of which the principal are one of the springs in the Montpellier Gardens, one of those at the Hospital, those at Harlow Carr, and the one at Starbeck, resemble the Strong Sulphur Water in their general constitution, but do not contain so large an amount of Chlorides and Sulphides although they are slightly richer in alkaline Carbonates.

The Strong Saline Chalybeates of which there are two, the Cheltenham spring and one in the Montpellier Gardens, are remarkable for the great quantities of Carbonic Acid and Chlorides that they contain.

The Pure Chalybeates, the principal of which are the Tewit Well and St. John's Well, although there are several others not only in and near Harrogate, but in almost every district, contain a far less proportion of salts than either of the above, and these are chiefly in the form of Carbonates with scarcely any Chlorides.

To recapitulate then, the Harrogate waters consist of four distinct classes, each of which has a certain marked peculiarity in its chemical constitution. Class I. The Strong Sulphur is very rich in chlorides and sulphides with a large bulk of free gases. Class II. The Mild Sulphur has nearly the same constituents as Class I, but in a less concentrated condition, and is also slightly richer in carbonates. Class III. The Saline Chalybeate is very rich in chlorides and carbonates but contains no sulphides. Class IV. The Pure Chalybeate contains a much smaller proportion of saline ingredients than either of the preceding; in fact it more nearly resembles the ordinary kinds of drinking water with a rather larger percentage of the carbonates of magnesia and iron. Let us now see what connection these four classes of water bear to the geological structure of the neighbourhood. My principal object is not so much to state any positive theory on the subject as to show that the source of the Harrogate springs need not be at any extraordinary depth, while at the same time it certainly is not at the immediate surface.

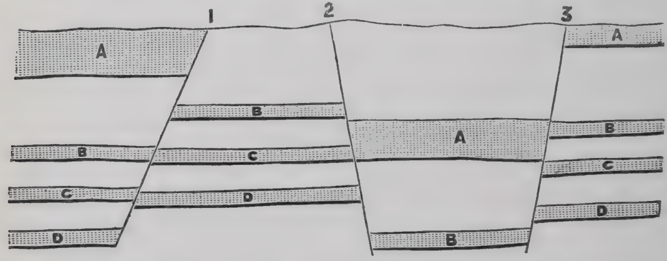
All the writers on this subject agree in considering that the mineral waters of Harrogate are derived from the peculiar geological structure of the neighbourhood, but they differ somewhat in their ideas as to their origin. Some, and they are rather a majority, consider that most, if not all the Harrogate mineral waters have a common source, and that the differences in the springs which are only partial, are occasioned by the different channels through which they reach the surface. Others again consider that each spring has its own independent source, and that it exerts no influence over any of the neighbouring springs as long as the water remains below the surface. Professor Phillips in his description of the geology of this part of Yorkshire considers that the Chalybeate and Sulphur springs of Harrogate originate from the junction of two lines of fault, one running nearly north-east, and the other about due north.* With regard to the first of these two lines of fault, it is very apparent that there is at least one if not several faults running in a more or less north-east direction and parallel to the main axis of disturbance; but from the manner in which the Harrogate anticlinal is enclosed both on the north and south sides by great ridges of grit striking across the country in an unbroken line for some considerable distance on either side of Harrogate, I do not think it is possible that the strata can be broken by a north and south line without the dislocation being more apparent, and even supposing there were a cross dislocation why should it be supposed to influence the mineral waters of Harrogate any more than at hundreds of other places where the same thing occurs. It seems much more probable that the real source of these springs is from the same or nearly the same beds of shale as those from which they issue at Harrogate; that they are confined to this group of strata throughout their entire course; and that the faults and disturbances in the neighbourhood of Harrogate exert only a minor influence on the peculiarities of the waters. If we examine the geology of the country to the west of Harrogate, we find that the strata in a general way consist of thick massive grits separated from one another by varying thicknesses of shale which are thrown into a series of slight undulations, but are not broken by any faults of considerable size. These beds, according as they partake of the sandstone or shaly character, become pervious or impervious to the passage of water; by this I mean that the grits and sandstones allow of the percolation of water through their substance in all directions, whereas the shales admit its passage only along the planes of lamination, and only then when they have become tolerably arenaceous. From this it follows that water which issues from a certain orifice, say the old Sulphur Well at Harrogate, would be confined throughout its entire course to the same strata, although probably not to exactly the same beds as those between which it springs at Harrogate unless the contiguity of the shales were broken by large faults.

---

* Phillips' Geology of Yorkshire, Part II., p. 253.

Now we have noticed above that there are no very large faults in the country under consideration. Small faults, I do not think, would make any interruption in the passage of the water as their effect would be rather to bend the shales than to cause any absolute disruption of them; and even supposing the strata to be broken this would not necessarily cause either a complete stoppage or even a partial diversion to the passage of the water.

For instance, we have seen above, that in the country under consideration, the same, or nearly the same beds of rock come to the surface throughout the entire distance, thus showing that the effect of all the faults taken as a whole, is to neutralize one another; so that a section taken along this line, any particular bed of strata would occupy the same position at either end.



Let us suppose four beds of strata A, B, C, D, broken by faults 1, 2, 3. Now the effect of the first fault is to throw C against B, that of the second to throw A against C, while that of the third is to throw B against A, thus giving B the same position as it occupied at first. Water entering any bed of strata, say C, would traverse any beds which were on the same horizon with it, namely, D and B, until it finally returned to the same strata, C, as that in which it was first collected. Now the effect of this would be, that the water would traverse many different beds of strata in its course, but its final exit would be from the same as that in which it first existed.

There is another circumstance to be taken into consideration, and that is the thinning out of some portion of the strata. The effect of this would be, that in the case of thinning out occuring towards the west, a stratum of water entering the ground in that region would become divided by the wedge-like nature of the rocks, so that two or more springs might still have had the same source in the first case, but have become gradually separated in their passage eastwards. Supposing on the other hand, that the thinning out took place in the opposite direction, the effect of course would be exactly the reverse; so that the water which entered the ground by several channels, would become united into one stream by the gradual dying out of the intermediate rocks.

One great proof of the separation of the several springs at Harrogate, is that the water in wells, often only a few feet apart, stands at totally different levels, and that the pumping from one well does not effect another. Whereas if there was a common source for the water in the immediate neighbourhood, the same pressure would be exerted in all cases, the water would stand at the same level in all the wells, and the pumping of the water in one well, would in an equal degree affect all the neighbouring wells. If this be true then, that each spring is confined throughout its entire course to the same, or nearly the same geological horizon as that from which it issues, its origin will be where the same strata came to the surface in the high ground to the west. The passage of the water will be after the manner of an inverted syphon; pressure will be exerted by the superior elevation of the strata to the west, which will force water up through the highly inclined rocks at Harrogate. The supply of water then, is derived from that which percolates the ground where the same strata, that is, the Yoredale Measures, come to the surface to the west of Harrogate. This is, as we have noticed before, along the valley of the Wharfe, near Bolton and Appletreewick, and beyond, being about twenty miles or more due west of Harrogate.

Dr. Bennett and other observers have noted that the quality of the springs varied with the amount of rainfall, and "that there was a marked relation between the amount of salts in a given quantity of the water, and the proportion of rain which had fallen prior to the date of each examination," the state of saline saturation increasing with the dry weather, and decreasing with the wet.* This fact at first sight would seem to argue that the springs were but superficial, and that the rain water had easy access to their sources; but, at the same time, it is just as probable that it is the rain falling on the western moorlands which causes this effect, as it is that which is collected at Harrogate. It would be a very interesting observation, and one which I believe has not yet been undertaken, to note the different periods of rainfall in these two localities, and to mark the effect they have on the saline saturation of the water. It is an observation that would require a good deal of care in drawing one's conclusions, but I believe we should find that the rain water falling absolutely at Harrogate, had very little effect on the springs.

Again, the temperature of the waters form what may be considered almost a direct proof that the sources of the wells are not superficial, while at the same time it also proves that they do not spring from an enormous depth. Dr. Bennett observes, "that the temperature of these sulphur springs during the summer, was always above that of the springs of fresh water in the vicinity, and that in winter, as in the month of January, when the thermometer had had fallen to 29°, these springs were never lower than 41°.

This shows that the springs are deeply seated enough to be somewhat affected by the internal temperature of the earth, but not so deep as to be beyond the influence of the external temperature of the air, or so deep as to become what we term warm or hot springs, like those of Bath and elsewhere. Of course this does not apply to the simple Chalybeate waters, which have no peculiar features other than those common to the ordinary class of springs, and some of which are freely acted upon by changes of temperature.

The next point to consider, is the different qualities of the water, and how this difference is occasioned. For this purpose the division into four classes mentioned above, is exceedingly useful.

---

* *Observation on the Sulphureous Springs of Harrogate*, p. 1.

If we look at the map we see that all the spring of Class I. the Strong Sulphur Water, issue from some of the lower strata which occur at Harrogate, in fact, within a short distance of the roadstone either above or below it.

Class II. The Mild Sulphur Waters issue also through lower rocks, but the majority, and in fact, the principal wells of this water are to be found coming from some of the highest strata that occur in the neighbourhood.

Class III. The Strong Saline Chalybeate Waters, although there are only two springs of this water, both issue from the same bed, and probably from the same portion of it.

Class IV. The Pure Chalybeate Waters rise irrespectively from both high and low measures, although some of the principal springs of this water issue from the highest strata, that is the Millstone Grit.

Each class of springs, then, in a general way, issue from different groups of strata; apparently there are exceptions to this rule, but I believe they are only apparent. For instance, the Chalybeate springs which rise near the Bogs, Low Harrogate, seem to issue from the rocks in that neighbourhood, which are some of the lowest beds in the district. This, I think, is not the case; it is more probable that they rise in higher strata to the north or south, and are kept beneath the surface of the Boulder Clay, which we know to occur in that locality, until they issue through the peat of that part of Harrogate known as the Bogs. It is this mixing of the two classes of waters which gives rise to the peculiar inky appearance of the springs in this locality. The sulphuretted hydrogen of the sulphur water combines with the iron from the Chalybeate springs, and produces the black dirty-looking water of these wells. If the sulphur water could be drawn off before it reaches the surface of the shales, and becomes contaminated with the Chalybeate, or if the latter could be diverted and confined to its original orifice, we should in all probability have perfectly pure sulphur springs. In fact, this is sometimes the case in frosty weather, when the superficial iron water becomes fixed, and we obtain the sulphur water pure and perfectly transparent. Accepting the hypothesis then, that each class of springs issue from, and are confined to, distinct bands of strata throughout the greater part of their entire course, it does not seem difficult to account for the difference in quality of each of these groups; but if on the other hand, we suppose that there is a common repository for all the wells, and that the water reaches the surface by faults and fissures in the strata, why is it that there is so much difference between these four classes of water? for surely if the supply were drawn from all sorts of strata indiscriminately, the chemical peculiarities would become mingled, and we should have nearly the same constituents in all the springs. Again, if the chemical impregnation of the water took place in its passage to the surface through joints and fissures, the sources from which it would derive its supply of salts must be comparatively near the surface, the amount would be but limited, and the quantity dissolved by the water would perceptibly diminish in course of time. But we know this is not the case, for several of these wells are recorded to have flowed for hundreds of years, and are known to give off an enormous amount of saline matter; Mr. Thackwray's wells alone producing as much as fifteen tons of salt in the year.

The stores from which these springs derive their saline matter must extend over a large area, and such an area is afforded by the Yoredale Measures, which occur at a short distance below the surface west of Harrogate. There are throughout this area undoubtedly several instances of the thinning out and alteration of the different beds, but they would probably occur at some little distance from Harrogate, and would in no way affect the distinct qualities of the water, which would not have been acquired until they had become confined to distinct channels. The chemical peculiarities of the water are such that we have no reason for supposing any source other than what these shales could supply when exposed to the action of water, especially if the water carried with it a certain proportion of the oxygen from the atmosphere. Mr. Hudleston in his paper before this Society, speaking on this point, says, "there is abundant evidence, both in this neighbourhood and elsewhere, of the quantity of organic matter, chiefly of vegetable origin, locked up in the Yoredale rocks. Hence it is not unreasonable to believe that the putrifactive distillation of such organic matter, acting very slowly, and through long periods of time, effects more or less the complete deoxidization of the sulphites, and that to this we owe the quantity of sulphide present in the Harrogate waters. The considerable quantity of carburretted hydrogen, and of nitrogen, found by Hoffmann, favours this view, which is much strengthened by the almost complete absence of oxygen, showing that the nitrogen present is due to organic decomposition. At the same time, the very slight traces of phosphoric acid would show that this mainly arises from vegetable matter."*

Taking all these things into consideration, it seems the simplest and most probable theory, for theory it must be; firstly, that each spring has its own independent source, with which it is connected by a separate and distinct channel formed by the alternating series of pervious and impervious strata which connects Harrogate with the hilly region to the west, for it is only from such a source as this that a large body of water could flow year after year with such slight alteration, both in quantity and quality; secondly, that the chemical impregnation of the water is caused during its passage through these strata, and that it is from this source that the bases of all the salts are derived.

In conclusion, let me observe that I do not offer this short exposition as an exhaustive treatment of the subject, my object has been rather to draw attention to the phenomena of these wells, now that all the neighbouring country has been geologically surveyed, the waters more carefully and frequently analysed, and we have more solid data on which to build an explanation of their peculiarities.

---

* *Proc. of the York. Geol. and Polytechnic Soc.,* New Series, Vol. VIII., p.p. 122 and 123.

THE MINERAL SPRINGS OF THE GRAND ANTICLINAL OF THE WEST RIDING: A FEW CHEMICO-GEOLOGICAL NOTES. BY GEO. OLIVER, M.D. (LOND).

WHEN invited to contribute a paper to the proceedings of this Meeting at Harrogate, I very much doubted if I could bring forward anything that would be of interest. On thinking over local subjects, the mineral waters of this town and the neighbourhood of course occurred to me first of all, because they are the most remarkable things in our natural history. But, inasmuch as Mr. Fox-Strangways and Mr. Hayton Davis had promised to take up this subject, I hesitated to do so: suspecting, however, that Mr. Fox-Strangways—whose geological survey of this district deserves our warmest thanks—would probably approach the subject mainly from its geological side, and that Mr. Hayton Davis would give you the gist of his extensive chemical knowledge of it, it occurred to me that I might take the chemical data along with the geological, and direct attention to a few facts relating to the other issues of mineral water, which, besides the more important ones of this locality, also flow from the lower carboniferous formations in the district to the west of Harrogate. I trust, however, that in bringing forward the following data and the inferences they suggest to me, I may look for that indulgence which the amateur may fairly claim who has merely given short intervals of leisure to their enquiry.

I will divide the subject of our study into three sections:

(1). A brief reminder of the formations and of the disposition of them in that portion of the West Riding that extends some 35 or 40 miles to the west of Harrogate, and in breadth about 10 miles to the north and south of it.

(2). The data pertaining to the issues of mineral water from these formations.

(3). Inferences and the bearing of data on questions of geological interest in respect to the mineralization of the waters.

I.—The Grand Anticlinal of the West Riding.

The strip of country, some 20 miles from north to south, and having its western limit in a line with Clitheroe, on the borders of Lancashire, and its eastern defined by the Magnesian Limestone of Knaresbro' and Ripon, is well characterized geologically by the general disposition of the strata, which is that of an anticlinal with the strike of the bedding from westward to eastward, and the dips northward and southward.

When, however, studied more in detail, the disturbances of the formations are found to constitute several anticlinal folds, running for varying distances between south-westerly and north-easterly points, rather than one grand uniform displacement. But there is one series of observed disturbances, indicating an anticlinal axis which can be made out for the most part throughout the whole district—namely, from Harrogate to Beckwith, Timble, Denton and Beamsley Moors, Bolton Bridge, Draughton, to the north side of Skipton, Broughton, and thence to the north of Clitheroe. Similar, but shorter lines of anticlinal dips can also be distinctly traced from Whitwell to Slaidburn and Malham, and also from Raygill to the south side of Skipton; and furthermore, I believe there is another but less sharply defied group of anticlinal displacements between Bolton and Aldfield, near Ripon. These four tracks appear to me to fairly indicate in a general way not only the most disturbed and crumpled part of the district, but also the most centric portions of the grand anticlinal, along which the lower beds—Yoredale and Mountain Limestone, and shales—either approach the surface, or are there exposed by denudation; while throughout on the north and the south the anticlinal is mainly flanked by massive beds of Millstone Grit and Shales.

To the west of Bolton Bridge the Mountain and Yoredale Limestone and Shales are found in the lower levels and valleys, and the Millstone Grit caps the hills; but to the east of the Wharfe the Carboniferous Limestone does not come to the surface, the Yoredale formations only crop up at Harrogate and in the district about three miles to the south-west of it, and various members of the Millstone Grit series form all the anticlinal and synclinal folds and crumplings.

II.—DATA PERTAINING TO THE ISSUES OF MINERAL WATER.

The mineral waters which flow from the anticlinal may be grouped as follows :—

1. Harrogate, Bilton, Starbeck, Harlow Car, Beckwith, and Crimple.
2. Bolton Wood.
3. Skipton, Broughton, Crickle, Langber, Elslack.
4. Wigglesworth.
5. Aldfield.

Possibly there may be others which have escaped my observation.* This list, however, does not include issues of chalybeate water which abound in a district like this, where the formations are highly ferruginous; it merely embraces those that are sulphuretted.

1. THE HARROGATE GROUP OF MINERAL WATERS.

(See diagrams I. & II.)

(a) The Bogs-Field Waters.—A small strip of ground—only 170 yards long and 40 yards across—on the Bogs-Field is remarkable in affording the issues of over 30 different mineral waters, all of which save one have been reached by sinking wells to various depths. The exception to which I refer is the Strong Hospital Sulphur, which rises nearer the surface than the other sulphur waters, and is probably the principal, if not the only, natural issue of sulphur water in this area; in this respect it resembles the Old Sulphur Well in Low Harrogate, and the Bilton spring, which are natural outflows.†

For the most part the sulphur waters flow into the most central of this group of wells; while the chalybeate ones are found mainly in the wells on either side (see diagram 1). The pure chalybeates near the Magnesia Well resemble other similar waters of the district (such as the Tewit and John's Wells on the Stray), in the fact that they derive their ferruginous impregnation from comparatively near the surface; in fact all observations of these Bogs-Field waters have shown that the salines, and especially the sulphide,

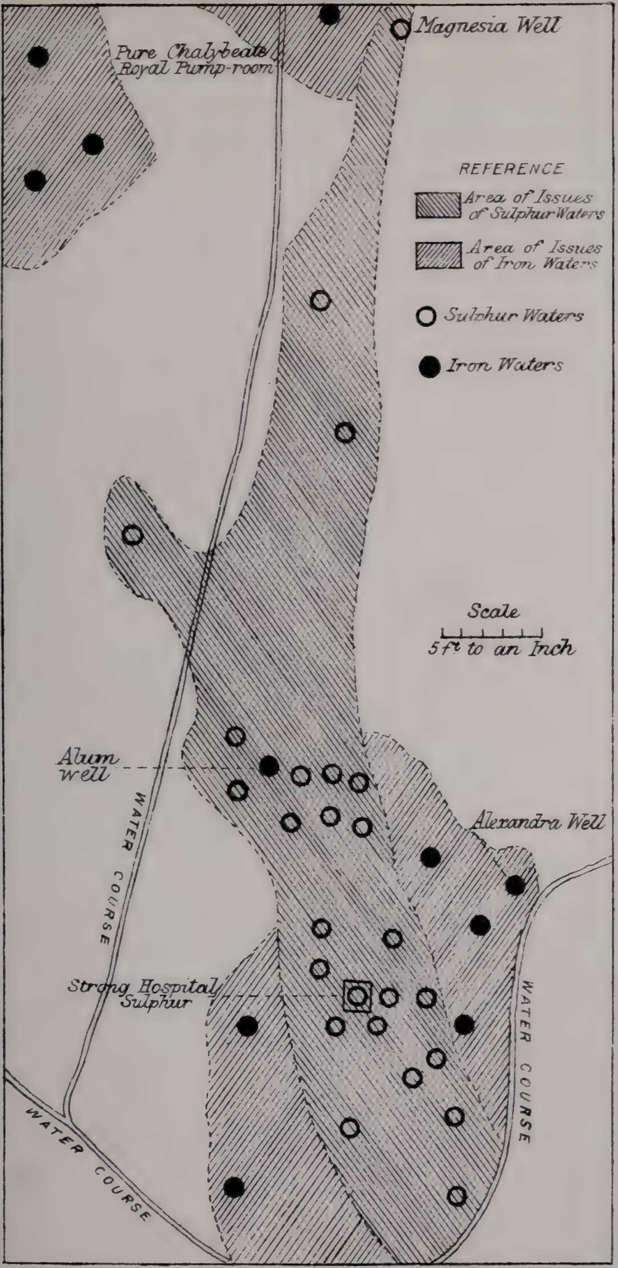
---

* Since writing the above, a friend has pointed out the existence of the Fooden Sulphur spring near Gisburn. It rises through the carboniferous limestone.

† When studying mineral waters from a geological standpoint, we should, I think, distinguish between the natural outflows and the artificial outlets provided by wells, for the former may illustrate some fact in nature which we should not overlook.

DIAGRAM 1

Proc. York. Geol. and Polyt. Soc., N.S. Vol. VIII., Pl. XVI.



A. Megson & Sons. Lithos Leeds.

THE BOGS-FIELD WELLS.

spring from deeper sources than the iron.

All about the Alum well, near the centre of this group of waters vegetation is very scanty; and the barren ground when moist, as after rain, affords an acid reaction to litmus paper. This fact is connected with the formation of Persulphate of Iron and Alum which drain into a shallow well, and which—like the production of alum from the oxidation of iron-pyrites—is derived from the action of the oxygen-laden rain reaching through the porous soil, superficial deposits of Sulphide or Iron (the black precipitate resulting from the mixing of the sulphur and iron waters). In the excavations lately made about the Alum Well, I noticed an abundance of this inky looking product in the sludge and shales; and the alum water ceased to collect below a certain level. During the past 150 years, at least, this water has been repeatedly discovered and lost: a fact which is doubtless to be explained by the superficial origin of the water, and by attempts to improve the yield of it by deepening the well.

If a line be drawn from the north side of Harlow Hill, in a north-easterly direction to the Old Sulphur Well in Low Harrogate, it will intersect this group of sulphur waters, and indicate the track of an anticlinal axis, of which we have direct evidence in the opposing dips of the Yoredale Limestone well exposed in the quarries on either side of the Bogs-Field, and it is believed that the waters rise through the shales which underlie this bed of Limestone.

(b) Low Harrogate Waters.—About forty wells of sulphur and iron waters are scattered over Low Harrogate. Here again it is easy to define in a general way the area of strong sulphur issues, and that of the iron saline waters: the former coinciding with the vicinities of the Royal Pump Room, and of the western side of the Montpellier Gardens; and the latter being found on the northern side of these gardens, and in front of the Spa Concert Rooms. An outlying group of weak sulphur waters are found near the Victoria Baths.

The most important issues in this area are the Old Sulphur Well, the Montpellier Wells, and the Chloride of Iron Water.

The Old Sulphur Spring.—On approaching the Royal Pump

Room from the Bogs-Field, the Yoredale Limestone is seen in the brook to dip at a low angle in an easterly direction, and at one point E.N.E. Some twenty yards to the south-east of these exposures is a remarkable group of eight sulphur wells in the cellar of the Royal Pump Room—distant from each other but a few feet, yet all differing in their proportions of salines and sulphides. The most important and best known of this group is the Old Sulphur Spring, which issues into a basin through fissures of the Yoredale rock and shales, shelving in a south-easterly direction, and but slightly inclined. Mr. Hayton Davis tells me the shales at the bottom of the other wells also dip south-east, but with varying degrees. The Old Sulphur Spring is the type of the whole of this group; for all these wells, with the exception of one or perhaps two, are strong in sulphur and in salts. And some twenty yards to the eastward of these issues is another strong sulphur well (Thrackwray's pump). The average proportion of salt in all these issues is over one per cent.—an amount as large as that found in several British brine springs. Within one hundred yards due east of the Old Sulphur Spring, is the strong Montpellier Sulphur Well, which yields a water almost identical in strength and composition.

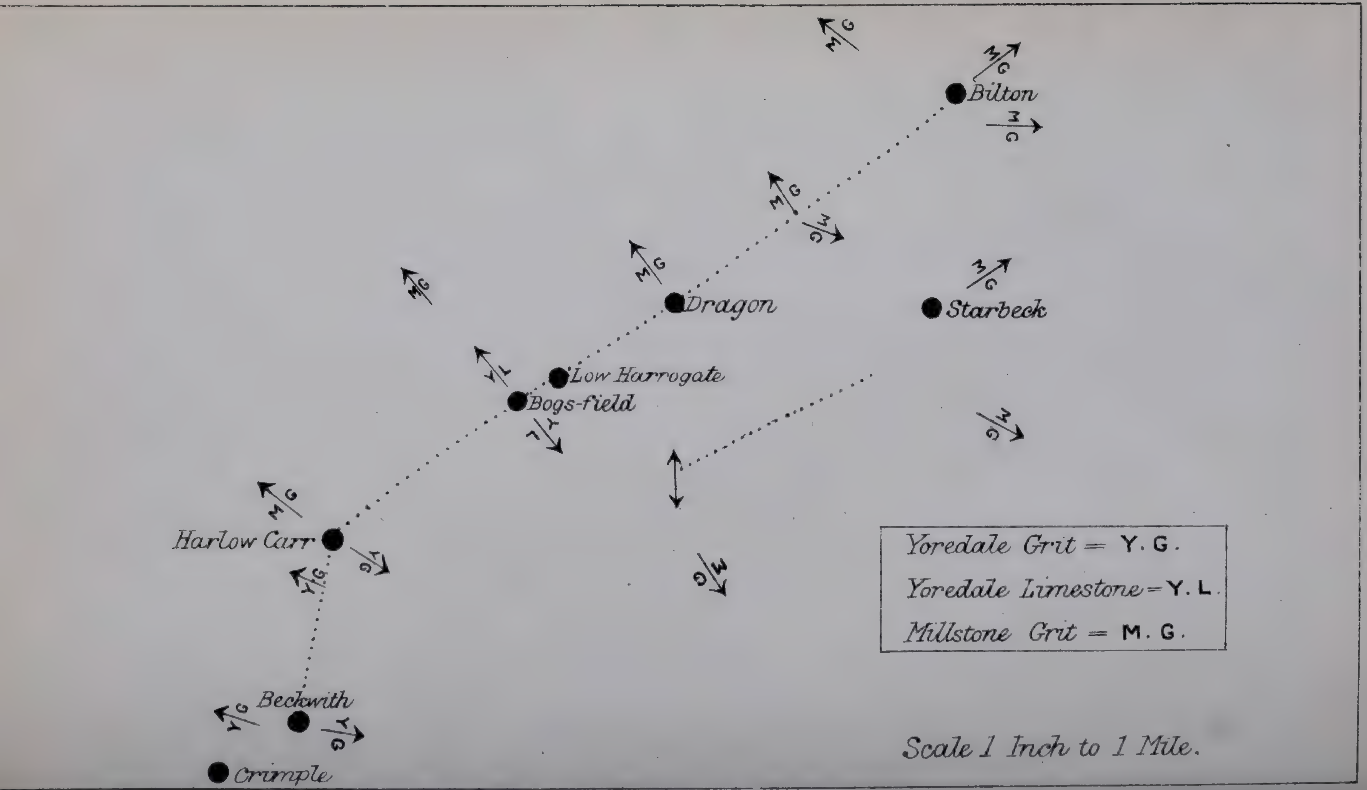
The Montpellier and the Chloride of Iron Waters flow from the dark blue shale that overlies the Yoredale Limestone. The dip of the bedding is N.W., with inclinations that vary from 20° or 30° in the Montpellier Gardens to very nearly perpendicular at the bottom of the Chloride of Iron Well. The strong dip of the shales at the latter site distinguishes it as the most disturbed portion of Low Harrogate.

(c) The Bilton and Starbeck issues.—If a line be drawn in an exactly north-easterly direction from the Old Sulphur Spring, it will, at the distance of 2½ miles, intersect Bilton Banks, on the declivity of which is a natural issue of sulphur water.*

The Millstone Grit, through which I believe the water springs

---

* It should be noted that when the drains were being laid near the Old Dragon Hotel, High Harrogate, an issue of Sulphur water was struck. This point is on the north-east track from the Old Sulphur spring to the Bilton spring. In the railway cutting midway between the Dragon and Bilton Banks, there are two good anticlinal exposures—close together—of Millstone Grit.



THE HARROGATE GROUP OF MINERAL WATERS.

to the surface, forms the bed of the Nidd which flows along the foot of the Banks; and, when the river water is clear, the observer can readily obtain a good notion of the semi-dome like disposition of the grit stone, which in this locality underlies the lower Magnesian Limestone forming the brow of Bilton Banks and the opposite bank of the river. In the bottom of the stream at a point north-east of the Sulphur spring the layers of sandstone are seen to dip strongly in a fan-like manner N.N.W. to E.N.E.; and, within a third of a mile on either side of this central point, other dips are found which extend the arc from N.W. to due E. This sulphur water is a vent for the escape of carburetted hydrogen gas, bubbles of which are constantly breaking on the surface: when collected, as in a test tube, the gas readily ignites. The presence of coal in the immediate neighbourhood of the spring is interesting in connection with this observation.

The *Starbeck Sulphur* water issues into wells which penetrate the shales of the Millstone Grit, as this formation dies away under the Permian beds. It is but a mile south of the Bilton source, at a lower level, and may possibly be an overflow of the latter.* The Bilton and Starbeck waters are almost identical in chemical composition.

(d) The Harlow Car, Beckwith, and Crimple issues.—A mile and a half S.W. of the Old Sulphur Well, in the bed of a small stream at *Harlow Car*, are several oozings† of sulphur water, and wells have

---

* When the cutting was made for the railway across the Stray, at Harrogate, Mr. Grainge observed at a short distance south of the middle bridge "a mass of rock of a triangular shape, on each side of which were to be seen the strata in regular beds receding north and south, and dipping downwards at an angle of about 45 degrees." This exposure, now covered up by turf, is viewed by him as the axis of elevation between Forest Lane, near Starbeck, and Beckwith Head (see *Geology of Harrogate*, by William Grainge, 1864). I am inclined to think that this observation (see diagram 2) along with the observed dips of the Millstone Grit beds to the eastward, suggest the existence of a ridge in the direction of Starbeck, but limited, however, westward by the different disposition of the older formations. The Harrogate portion of the anticlinal may therefore be said to form two lines of elevation, one terminating at Bilton, and the other at Starbeck. It is well-known that the central line of an anticlinal is frequently broken (as in Low Harrogate), and that not unfrequently two or more crumplings take the place of one.

† I should remind you that the ooze of sulphur water in the bed of a stream, is indicated by a light yellow or whitish streak in the direction of the current.

been sunk for the reception of it. The water issues from the shales below the Millstone Grit in a piece of highly disturbed bedding—the first shales discoverable on the N.W. side of the anticlinal axis on the north side of Harlow Hill. A great fault is believed to run through this spot for several miles to the S.W. and N.E.

One mile nearly due S. of Harlow Car is Low House, *Beckwith*, near which in a small stream which joins Crimple Beck, you will find some thinly bedded hard sandstone (the Yoredale grit, well exposed in the quarry on the road close by) dipping at a very high angle, and forming an anticlinal axis. At this point a sulphur water † flows into the side of the brook, where the strike of the bedding suddenly turns from E.N.E. to almost due N. in the direction of Harlow Car. This sharp turn of the anticlinal axis is interesting in respect to the issue of sulphur water through the highly disturbed bedding of the sandstone.

Numerous small jets of sulphur water are also readily detected issuing from the Yoredale shales seen in the bed of Crimple beck, about a quarter of a mile to the south of Low House.

The chemical composition of the Beckwith Sulphur water is essentially that of the Harlow Car issues: the sulphide in both being associated with a good proportion of alkaline carbonates, and with a small amount of chlorides. They also resemble the Bilton and Starbeck issues to the east of Harrogate, in containing alkaline carbonates—salts which are not found in the strong saline waters of Harrogate.‡

2.—THE BOLTON WOODS SULPHUR SPRING.

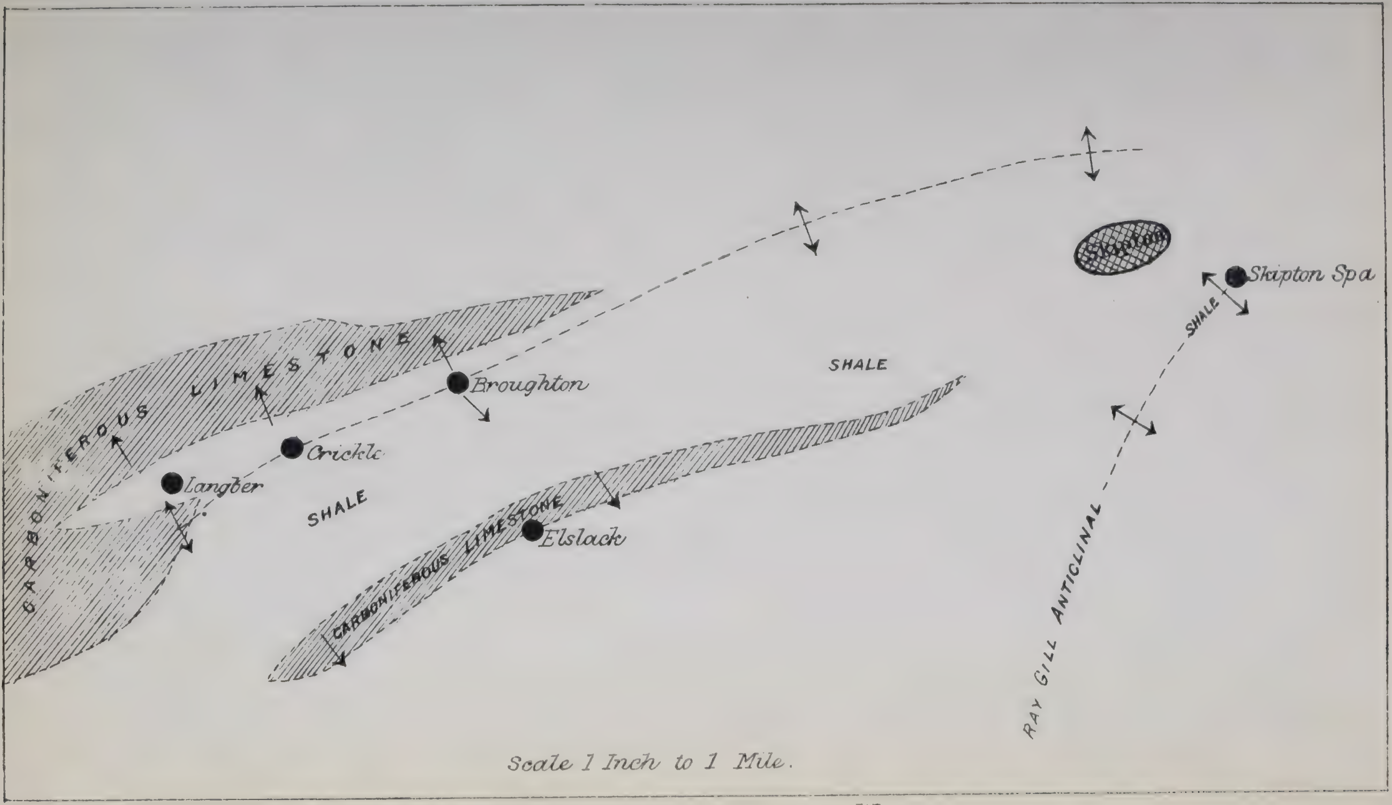
The highly crumpled district of Bolton Bridge, 13 miles to the west of Harrogate, also provides a sulphur water which flows in Bolton Woods from the Yoredale shales. The association of this

---

† Some few years ago I isolated this water by digging down to the shales through which it rises, and by fixing a drainage pot. This issue is now, however, silted up with sand; but the sulphur water has since broken through the laminated and highly ferruginous sandstone on the opposite side of the stream, and has there abundantly precipitated the iron as black sulphide, and has besides left whitish streaks of uncombined sulphur.

‡ This statement is not invalidated by the fact that Mr. Hayton Davis has lately found alkaline carbonates in some mild sulphur waters near the Victoria Baths, and in the Crescent well: for these are not representatives of the strong saline issues.

Diagram 3



THE SKIPTON GROUP OF SULPHUR WELLS.

issue with the centric disturbances of the anticlinal displacements is well-known in the section of them exposed by the denuding agency of the Wharfe.

3. The Skipton Group of Sulphur Waters.

(See diagram III).

(a) Skipton Sulphur Water.—On the south side of Skipton, the Limestone shales are bent very sharply into an anticlinal axis, from the ridge of which the Skipton Sulphur water flows. This anticlinal disturbance can be distinctly traced in a south-westerly direction to Ray Gill.

(b) Broughton, Crickle, Langber, and Elslack Sulphur Waters.—This group of sulphur issues are intimately associated with the disturbed limestone and shales to the west of Skipton.

The *Broughton* water (3½ miles W. of Skipton) rises out of the shales which intervene between two beds of Carboniferous Limestone forming the hilly ground to the north and south of them, and having sharp dips in opposite directions—north-west and south-east. It flows from the anticlinal axis, which can be traced on the one hand to the fine exposure on the north of Skipton, and on the other towards the north of Clitheroe.

The site of *Crickle* Spa—marked on the Ordnance Map—occupies exactly the same geological position as that of Broughton, from which it is one mile to the S.W.*

The sulphur water issues of *Langber* about half a mile S.W. of Crickle, flow into a small brook which runs over the broken up Mountain Limestone, forming the anticlinal axis in this part. The water rises through the bedding on the northern side of the axis.

The *Elslack* Sulphur water is also connected with the same disturbance of the Limestone as provides the foregoing issues: it does not, however, flow from a point so near the turning dips as these occupy, but from the bed of Limestone (or the shales below it) half a mile to the south of Broughton Spa, that has its fellow close to the latter on the opposite side of the axis.

---

* When I visited Crickle I found the basin belonging to the spa transported to the middle of a field. No doubt there are sulphur issues in the brook close by, but at the time I did not detect them.

4.—The Wigglesworth Sulphur Water.

I have not yet observed the geological relations of the *Wigglesworth* source on the Yoredale shales.* Its position on the map corresponds with the track of the great anticlinal that runs in a north-easterly direction from Chipping and Whitwell to Slaidburn and thence to Malham.

5.—The Aldfield Sulphur Water.

I am inclined to think that this issue of sulphur water marks the termination of a west to easterly line of anticlinal disturbance, just as do the Old Sulphur and the Bilton springs in respect to the Harrogate disturbance. But I have not studied the district northward with sufficient care to enable me to speak on this matter with any confidence. The water rises through the shales that underlie the massive Millstone Grit bed, well exposed at Sawley and Grantley, that here shelves away in a semi-dome-like fashion at low angles of displacement under the Magnesian Limestone of Studley Royal, immediately to the east of Aldfield. Bubbles of carburetted hydrogen gas are seen to break in rapid succession on the surface of the water, as at the Bilton Spa.

III.—Questions relating to the Mineralization of the Waters.

The foregoing data appear to me to establish the position, that the natural issues of the mineral waters of the West Riding anticlinals are found along those lines of disturbance where the lower beds approach the surface—in a word, the lines of elevation.

On, however, leaving these matters of direct observation for the insecure ground of speculation as to the sources of the mineralization of the waters, we cannot but hesitate at every step, knowing that we must merely rely on the balancing of probabilities in favour of any particular view.

(A) The derivation of the Constituents.

The constituents of these springs suggest some questions of geological interest: as for example, in respect to the origin of the

---

* See the maps accompanying *The Geology, Natural History, and Prehistoric Antiquities of Craven in Yorkshire*, by L. C. Miall, Professor of Biology in the Yorkshire College, &c., and *West Yorkshire: Geology, &c.*, by James W. Davis, F.G.S., &c.

Salt, the Sulphide, the soluble compounds of Barium and Strontium, and the Proto-chloride of iron. I will pass in review some of the principal theories that may be broached to account for the presence of these various salts.

1.—*Chlorides.*

The Harrogate waters (the issues of the Bogs-Field and Low Harrogate) in at least one leading feature of their chemical constitution differ from the others: they contain a very much larger proportion of chlorides—in fact, the best examples of this group of springs are strong salt waters, as well as being sulphuretted. For example, the Old Sulphur Well, and the Strong Montpellier Sulphur contain at least four times as much salt as is present in the Aldfield source. though this is more freely charged with chlorides than the water of the other issues outside Harrogate.* One issue only (the Old Sulphur Spring) throws up annually over six tons of salt, and the aggregate output of all the wells cannot be less than from 80 to 100 tons—an amount which is probably exceeded. This fact provides a general notion of the large amount of saline material constantly in process of removal from the formations through which the mineral water circulates before it discharges itself from the limited area comprised by the Bogs-Field and Low Harrogate. Whence is it derived?

(1) *Direct communication with sea water.*—You will be aware that Sir Charles Lyell† and some other eminent geologists, entertained the theory of the direct passage of sea water through the porous and fissured bed of the ocean, and along subterranean conduits formed by faults and rents of the rocks to the issues of saline water, even though situate many miles inland. Two principal difficulties present themselves in applying this hypothesis to the Harrogate salines—one physical and the other chemical; namely. altitude (can the water of the ocean rise above the sea level?), and the presence of an average ratio of 10 per cent. of soluble sulphates in the saline residue of sea water. So that should it even be conceived possible

---

* I am indebted to Mr. R. Hayton Davis, F.C.S., for skeleton analysis of the various waters.

† See *Principles of Geology*, 6th Ed. Vol. 1., pp. 396, 397.

Samples taken Feb., 1880. Grains in imp. gallon.

	SO_3	CL.	Alk. Carb.	Total Solids
Skipton	2.4	12.7	Present	55.5
Broughton	Present	74.6	None	215.5
Langber	Present	59.5	——	198.3
Elslack	Present	2.2	Present	28.7
Aldfield	Present	153.5	None	294.7
Wigglesworth	Present	6.2	Abundant	66.5
Harrogate Old Sulphur	None	619.6	None	1061.7

for the water of the ocean to permeate as far inland as, and to the altitude of, Harrogate, how are we to account for the abstraction of the sulphates which form so large a proportion as one-tenth of the solid constituents of sea water?

(2) *Sediments and precipitates from the ancient sea in which the carboniferous rocks were deposited.*—I need scarcely remind you that the Mountain Limestone exposed to the west of Bolton Bridge implies an origin in clear, deep sea water, and that the massive beds of Gritstone that flank the anticlinal, and that abound most to the east of the Wharfe are the sea-shore formations of open tidal seas. Both these marine conditions are obviously not favourable to the deposition of saline matter. Not so, however, the transitional Crinoidal Limestone of the Bogs-Field and Low Harrogate; for the only fossil organic remains it presents—the joints of small encrinites—suggest a shallow sea, or other conditions unfavourable to the development

of marine forms of life, but such as possibly afforded at times opportunities for saliferous precipitation. The presence of iodine and bromine (as, for example, the definite quantities recorded by Professor Thorpe in his analyses of the Old Sulphur Spring and the Montpellier Strong Sulphur) in these waters favours the marine origin of their salines: and furthermore the detection of manganese in the Chloride of Iron water, in quantity sufficient to be determined by Mr. Bothamley, suggests the same conclusion, for Dieulafait has shown that manganese bicarbonate exists in the waters of all seas and oceans, and Berthelot has pointed out that in contact with oxygen it becomes binoxide, which sinks and accumulates on the ocean bed, where a large quantity of manganiferous mud is found.

(3) *Volcanic Salt.*—Sir Charles Lyell was favourable to the volcanic origin of the saline impregnation of many mineral springs. He says, "as muriate of soda is one of the products of volcanic emenations, and of springs in volcanic regions, the original source of the salt may be as deep-seated as that of lava." (*Principles of Geology*, 10th Ed. vol. I., p. 411.)

There is, however, no evidence whatever to show that an active volcano ever existed here: and though we may speculate as to the share which volcanic agency may have taken in displacing the water-born strata, there are no facts to warrant a belief in this mode of origin of the salt. Besides, there is the undoubted fact that of all the mineral waters distinctly referrible to vulcaninity—such as those of the Pyrenees, of the Auvergne, and of active volcanic areas—there is not one that can in any degree approach the large proportion of salt present in the brine issues of Harrogate.

2. THE SULPHIDE.

Various theories have been advocated from time to time in order to explain the presence of sulphide in the Harrogate and other sulphur waters. I will pass some of them briefly in review.

(1) *The reduction of Sulphates into Sulphides or Sulph-hydrates* by means of living organisms (confervæ)*, or by organic matter—

---

* M. Blanchard's experiments with confervæ taken from a sulphuretted mineral spring conclusively show that these organisms, when a soluble sulphate is present, live at the expense of the combined oxygen, and in this way sulphurate the water. See *Compt. Rend.*, vol. 89.

whether vegetable or animal—in the process of decay.* It has long been supposed that at the ordinary temperature peat, bog soil, or lignite will effect this reduction; but experimenters have conclusively shown the groundlessness of this opinion.† The organic matter must be in a state of active decay. All the theories that hang on this explanation cannot, however, apply to the Harrogate sulphur waters, for soluble sulphates are not present; and, if it be said they are absent because completely converted into sulphides, we can point to the ferruginous saline waters which are also sulphate—free.

When the Sulphide of a mineral water can be traced to the reducing agency of decaying animal or vegetable tissue on soluble sulphates, these not only appear along with it, but some of the organic matter also. This fact is well illustrated by the Strathpeffer sulphur waters, which contain from two to three grains of organic matter to the gallon.§ Not so the Harrogate sulphur waters, in which organic matter when detected at all has been recorded by analysts as mere traces—such as in fact appear very frequently in ordinary springs.

(2) *Decomposition of Iron disulphide*—Pyrite (the form of sulphide of iron widely diffused through sedmentary beds, and frequently found in the lower carboniferous formations) is believed by some to yield a soluble sulphide when decomposed by carbonic acid and alkaline carbonates. But, I think, this source of sulphuration does not seem very probable when we call to mind that pyrite when free from marcasite (the less stable form of iron sulphide more particularly found in the secondary and tertiary fossiliferous rocks) resists weathering for very long periods—a fact indicative of its chemical stability—and that it has yet to be demonstrated that, in the absence of a temperature decidedly above the ordinary, it will

---

* Strathpeffer is a good example of a sulphur water derived directly from a rock through which animal remains slowly decomposing are diffused—the fish-bed schist of the old red sandstone, a formation which when broken emits the peculiar fœtid odour of decaying animal matter. See *Old Red Sandstone* by Hugh Miller.

† See Lancaster. *An account of Askern and its Mineral Springs*, 1842. Also E. Blanchard *Compt. Rend.*, vol. 89.

§ See *The Sulphur Waters of Strathpeffer*, by D. Manson, M A., M.D.

deliver up its sulphur in a soluble form, in the presence of water charged with carbonic acid and alkaline carbonates. There are, however, the facts, that the atmosphere of coal-mines not unfrequently contains sulphuretted hydrogen, and that sulphur springs are found in the coal measures where pyrite is frequently met with; but even in such cases we cannot be quite sure that soluble sulphides have not been formed as well as the pyrite, and are merely liberated by the mining operations.

(3) *Volcanic Sulphide.*—I merely mention this possible source of sulphuration, in favour of which there does not appear to be any direct evidence.

(4.) *Fetid Limestone.*—Certain portions of limestone are occasionally met with in the Craven district which, on being broken up or pounded, distinctly emit the odour of sulphuretted hydrogen. They probably contain some soluble sulphide, possibly derived from the sulphur of the proteid or sulphur-holding tissue of the lime building organism having passed into organic combination.* May not a bed of calcareous stink-stone approach the surface along the lines of anticlinal disturbance, and account for the sulphuretted character of the issues there observed? This is of course a mere conjecture, but I think it is a matter worthy of further enquiry.†

3. BARIUM AND STRONTIUM.

Among the springs here referred to, the Harrogate waters stand alone in containing barium and strontium in notable proportions, these constituents not being present in the other issues. But the presence in the latter of sulphates, which precipitate the soluble salts of barium and strontium, sufficiently accounts for the difference; ‡

---

* "In some quarries in the Carboniferous Limestone of Ireland, as mentioned by Mr. Jukes, the freshly broken rock may be smelt at a distance of a hundred yards when the men are at work, and occasionally the stench becomes so strong that the workmen are sickened by it and require to leave off work for a time."—*Text-book of Geology*: Archibald Geikie, F.R.S., 1882.

† The reader will bear in mind, that the Mountain Limestone which crops up freely in the western part of the West Riding, probably forms the floor of a great portion of Yorkshire, and underlies Harrogate.

‡ The veins of barium sulphate seen in some limestone quarries to the west of Bolton Bridge (Ray Gill, &c.), may be examples of the precipitation here referred to; the sulphate-charged surface water having deposited the barium brought up by subterranean currents.

for whether a mineral spring shall bring these constituents, present in the formations whence it is derived, to the surface, is a matter determined by the sulphates encountered as the water rises to its issue. In giving due weight to this fact we must bear in mind that in Harrogate the greatest care has been taken, especially in recent years, to exclude by water tight wells, etc., the inlets of surface water which generally contain sulphates. But even here it has been found that a newly opened well will deliver a sulphate-holding water for a certain time, which may at last become sulphate-free. There are besides those of Harrogate many sulphate-free brine waters which contain barium and strontium: such, for example, as the mineral water issues from the coal formation of the Alleghany River district, and several of the Canadian waters described by Dr. Hunt.§ The frequent occurence of barium carbonates (witherite) along with the metallic sulphides in the lower carboniferous rocks, appears to be the only geological fact, at present known, suggestive of an explanation of the barium impregnation.

4. PROTOCHLORIDE OF IRON.

The appearance of this salt in large quantity in the Imperial Chalybeate Saline water—perhaps the most remarkable mineral spring in Europe—is a chemico-geological curiosity, and notwithstanding the valuable analytical evidence provided by several eminent chemists, it remains a puzzle to those who attempt an explanation of its origin. Is it derived from chemical decomposition, or from some existing deposit?

(1) *Chemical decomposition.*—The only probable reaction is that between iron sulphate and barium chloride, which yields ferrous chloride and barytes.

$$\mathrm{Fe\,SO_4 + Ba\,Cl_2 = Fe\,Cl_2 + Ba\,SO_4}.$$

I have pointed out the fact that on the Bogs-Field iron sulphate is generated by oxidation of iron sulphide; may there not be a similar convertion, hitherto unobserved, going on in the neighbourhood of the Chloride of Iron well? But this view must appear doubtful when we consider what a large quantity of barium chloride it necessitates—very much larger than has yet been met with in, or is likely to be furnished to the issues of a mineral water; and when it is remembered that, notwithstanding the repeated periodical scrutiny of the water during the past twenty years, iron sulphate has never been found as a constituent. Still in the course of time, as fresh evidence may accumulate, it will be well to keep in mind this *possible* origin of the ferrous chloride, for in the other springs (only two) in Europe in which it has been met with—namely Alexisbad and Buckowina—Ferrous sulphate has been discovered, and in Buckowina alum also. This ferrous chloride well of Harrogate is, therefore, the only water of similar composition at present known that does not contain sulphates.

---

§ The saline water of Boston Spa on the Permian beds, about 12 miles S.E. of Harrogate, is also sulphate free, and contains barium. See *Contributions to the History of the Mineral Waters of Yorkshire*, by Prof. Thorpe, F.R.S. The close family likeness of this water to the Harrogate Salines points to a similar source in the carboniferous beds that underlie the permian formations in this locality.

(2) *Deposit of Ferrous Chloride.*—In the remarkable saliferous deposits of Strassfurt,* ferrous chloride has been found associated with potassium chloride ($FeCl_2\ 2KCl + 2\ H_2O$).† At present this observation may seem devoid of obvious bearing on this difficult question: but as enquiry advances it may possibly provide a link in the chain of evidence. With the same view I will merely mention the yellow masses of perchloride of iron found so abundantly in the openings and clefts of fumeroles and in the interior of craters, and the reduction of this ferric salt to the condition of protochloride in the presence of sulphuretted hydrogen. In the absence of positive evidence of volcanic action—unless the disturbed strata be accepted as such—we can but speculate on the mere possibility of some volcanic products having been intruded into the formations of aqueous origin.

Such are a few of the debateable questions raised by the constituents of these waters. Though they show you the difficulty of tracing with any degree of probability the sources of mineralization, they nevertheless, when studied with due caution, may suggest to the geologist open to all available evidence, interesting facts and matter for speculation that cannot be gleaned by direct observation.

---

* The different salts are stratified according to their solubilities.

† *Journal of the Chemical Society*, May, 1881.

(b) *The variety of the Harrogate waters.*

In Harrogate that which astonishes all observers is the large number of different mineral waters which arise side by side; in fact, in such close proximity that over seventy issues flow from the small aggregate area of only four hundred and eighty yards by two hundred and thirty; and, moreover, year by year preserve their individuality. This differentiation of the chemical composition of the issues, however, does not merely apply to the various wells, but even to the bore-holes;* these diminutive inlets of the mineral waters may, therefore, be regarded as miniatures of all the wells.

Whence all this variety of composition within so limited a space? It is difficult, if not impossible, to form a consistent notion of all the several causal conditions that determine this diversity; I say 'several' because doubtless every separate issue of mineral water is the resultant of many causes. In viewing this intricate question we must take into account geologic arrangement of pervious and impervious strata, which provide separate channels for the circulation of water in the shales; chemical reactions between constituents contained in the water and those locally distributed; the disposition which solutions of saline matters have to arrange, and to maintain themselves at different levels according to density; and various degrees of dilution by local currents of supply water.

But notwithstanding all the individual variations in composition there is, I think, clear evidence of the existence of one common source—whether the water be sulphuretted or ferruginous. This fact is shown mainly by the chemical similarity of the saline constituents common to all the waters; for when these are viewed apart from the sulphide or iron salt with which they are associated, they present a fairly uniform per centage composition—namely, from eighty to ninety per cent. of Sodium Chloride, small proportions of other chlorides and of the carbonates of the alkaline earths; and sulphates are absent from by far the majority of the issues. This position is, moreover, corroborated by the detection of Barium in all the saline waters shortly after the discovery of it, about twenty years ago, in the Chloride of Iron well.

---

* See the observations of Mr. Hayton Davis on the bore-holes of the Kissingen, and of the Chloride of Iron wells in his paper *On the Mineral Wealth of Harrogate.*

Undoubtedly local chemical changes contribute towards individualizing the various waters. The following reactions have been pretty clearly established.

(a) The reaction between *Carbonate of Iron* and *an Alkaline Sulphide* as expressed by the formulæ:

$$\mathrm{Fe\,CO_3 + Na_2\,S = Fe\,S + Na_2\,CO_3.}$$

$$\mathrm{Fe\,CO_3 + 2\,(Na\,HS) = Fe\,S + Na_2\,CO_3 + H_2S.}$$

The insoluble but finely divided precipitate proto-sulphide of iron, will probably fill in the cracks and fissures of the different channels, and, by coating over the shales will further contribute to the isolation of currents of saline water containing Carbonate of Iron or a sulphide—just as one or the other of these constituents may predominate. This re-action suggests the source of the alkaline carbonates present in the Bilton, Starbeck, Harlow-Car, and Beckwith issues, which do not contain the Chlorides of Calcium and Magnesium (see (c)).

(b) The reaction between *the soluble salts of Barium and Strontium* and *Sulphates.*

$$\begin{matrix}\mathrm{Ba}\\ vel\\ \mathrm{Sr}\end{matrix}\left\{\begin{matrix}\mathrm{Cl_2}\\ vel\\ \mathrm{CO_3}\end{matrix}\right. + \mathrm{Ca\,SO_4} = \left.\begin{matrix}\mathrm{Ba}\\ vel\\ \mathrm{Sr}\end{matrix}\right\}\mathrm{SO_4} + \mathrm{Ca}\left\{\begin{matrix}\mathrm{Cl_2}\\ vel\\ \mathrm{CO_3}\end{matrix}\right.$$

The precipitated Barium and Strontium Sulphates will gradually plug up any cavities or rents in which they are deposited.

(c) The reaction between *Alkaline Carbonates* and *the Chlorides of the Alkaline Earths.*

Alkaline Carbonates cannot co-exist along with the chlorides of Calcium and Magnesium:

$$\mathrm{Na_2\,CO_3} + \left.\begin{matrix}\mathrm{Ca}\\ vel\\ \mathrm{Mg}\end{matrix}\right\}\mathrm{Cl_2} = 2\,\mathrm{Na\,Cl} + \left.\begin{matrix}\mathrm{Ca}\\ vel\\ \mathrm{Mg}\end{matrix}\right\}\mathrm{CO_3}$$

Hence in the saline waters of Low Harrogate and the Bogs-Field, which contain these chlorides, Alkaline Carbonates are not found—being broken up as soon as formed—but they survive in the issues of sulphur water immediately outside Harrogate (see (a)).

(d) The reaction of *Protochloride of Iron* with *the Carbonates of the Alkaline Earths.* Carbonate of Iron and the Chlorides of the

Alkaline Earths being formed :

$$\mathrm{Fe\,Cl_2} + \left.\begin{matrix}\mathrm{Ca}\\ \textit{vel}\\ \mathrm{Mg}\end{matrix}\right\}\mathrm{CO_3} = \mathrm{Fe\,CO_3} + \left.\begin{matrix}\mathrm{Ca}\\ \textit{vel}\\ \mathrm{Mg}\end{matrix}\right\}\mathrm{Cl_2}$$

Hence the Chloride of Iron water does not contain earthy carbonates, but holds in solution large proportions of Carbonate of Iron, and Calcium and Magnesium Chlorides.

But this reaction is not merely supported by the present composition of this remarkable water ; it is furthermore illustrated by its chemical history, which besides shows us how the constitution of a mineral spring may be completely revolutionized by the admission of a new constituent.

The present Chloride of Iron well was sunk in 1819, when (and in 1829) the water was carefully analysed by Dr. Hunter, who determined the presence of salines along with Proto-carbonate of Iron ; and this analyst—aware of the observation made by Dr. Thos. Garnett about 1790, to the effect that Chloride of Iron existed in a chalybeate water close to the well under examination*—specially tested for, but failed to discover, iron combined otherwise than with carbonic acid.† The correctness of Dr. Hunter's analysis was confirmed by Drs. Garnett, Murray, and Scudamore. At this time the percentage proportions of the carbonates and chlorides of calcium and magnesium resembled those now present in the other saline waters, *e.g.* the Old Sulphur Spring which fairly represents them. But in 1854 Hoffmann, while maintaining the general chemical features of the water, recorded a considerable increase of the chlorides of the Alkaline Earths, and of the Carbonate of Iron. This alteration is so considerable, that one might suspect that Chloride of Iron may have been overlooked by Professor Hoffmann ; this theory is, however, opposed by the presence of carbonate of lime, and is moreover improbable when one bears in mind the well-known accuracy and skill of the analyst. These facts appear to me to support the notion that in 1854 Proto-chloride of Iron was already mingling with the constituents of the water, as determined by previous analysts, and raising the relative proportions of the Magnesium and Calcium Chlorides, and of the Carbonate of Iron; but the amount of it was as yet insufficient to remove all the Carbonate of Lime, and to establish an independent existence in the water.

---

* "In a chalybeate water, near the road (Ripon road), and not far from the Crescent Garden, the iron is dissolved in muriatic acid."—*A Treatise on the mineral waters of Harrogate*, by Thos. Garnett, M.D., 1792.

† See "*Essay on two mineral springs recently discovered at Harrogate, and on the springs of Thorpe Arch and Ilkley, &c.*—by A. Hunter, M.D., 1819.

When, however, this saline chalybeate was analysed eleven years afterwards (1865) by Dr. Muspratt, the long lost Chloride of Iron, which had not been encountered for seventy-five years, was again discovered—it having found its way into the sources of the Chloride of Iron water, and had there at last predominated over the earthy carbonates. Then the Calcium and Magnesium Chlorides and the Carbonate of Iron were again found, as in 1854, in large proportions; and the Carbonates of Lime and Magnesia had vanished. This newly acquired constitution of the water has during the past twenty years been uninterruptedly maintained; and will doubtless continue so long as Chloride of Iron gains access to the well, in quantity sufficient to prevent the appearance of the earthy carbonates.

The foregoing facts are epitomized in the following table constructed from the data provided by the various analyses.

IN 100 PARTS OF THE TOTAL RESIDUE.

		Old Sulphur Well.	*Chloride of Iron Well.*			
		1875.	1819, 1820, 1821(2), 1829.*	1854.	1865-6.	1880.
Sodium Chloride		85	8.7	55.5	44.6	43.5
Calcium and Magnesium	*Chloride*	8	9.3	30.0	46.8	32.0
	Carbonate	3.4	1.5	2.6	*Nil*	*Nil*
Iron Carbonate		*Nil*	1.1	1.6	2.3	2.3

Parts per cent. of total solid residue.

	Sodium Chloride.	Calc. and Magn. Chlor.	Iron Carbonate.
Hunter, 1819	87	8.6	1.4
Scudamore, 1820	87	9.2	1
Murray, 1821	84	11.6	1
Garnett, 1821	87	9.2	1
Hunter, 1829	90	8.3	1.2

---

* All these analyses provide fairly uniform results.

The foregoing notes appear to me to support the following conclusions:—

1. The saline and sulphur waters of the anticlinals of the West Riding, issue in proximity to the lines of Elevation.
2. The large proportion of Chlorine Salts present in the Harrogate saline waters, whether sulphuretted or ferruginous, is of marine origin and is probably derived from the ancient sea in which some of the carboniferous rocks were laid down.
3. The theory of the reduction of sulphates by means of vegetable or animal organic matter, frequently, if not generally, held by geologists as applicable to all sulphur waters, cannot be entertained as the explanation of the sulphuration of the Harrogate waters: chemical evidence being opposed to its adoption.
4. A soluble salt of Barium exists in relatively large quantity in the sulphate-free waters of Harrogate: and is probably derived from Witherite, which has been found in association with metallic sulphides in the lower carboniferous rocks.
5. The Harrogate saline waters are all derived from a common source: the differences in composition—even those observed within very narrow limits—being accounted for by the separate channels provided by the shales, which convey the waters to the natural issues, or the bore-holes of wells; by chemical re-actions; by the disposition which solutions of salt have to arrange themselves in certain levels, according to concentration; and by the varying amounts of supply-water which reach the various outflows.
6. The chemical history of the Chloride of Iron Well, is an interesting illustration as to the important part played by chemical re-action in the production of a mineral water, which—in the case of an artifical outlet provided by a well—may only acquire a settled composition after the lapse of many years.

THE MINERAL WEALTH OF HARROGATE. BY R. HAYTON DAVIS, F.C.S.

WHILE recently making a complete examination of all our public sulphur springs, I was much impressed with the enormous quantities of salines which must be discharged annually by the sulphurous and ferruginous waters of Harrogate; not only by those employed medicinally, but including the innumerable oozings in the beds of streams, and more particularly in various parts of the surface of the Bog-Field.

Having determined the yields of a large number of the springs which up to the present had been only roughly estimated, I have had data before me to calculate with an approximation to correctness, the output of solid constituents by our mineral waters; a matter which I hope will be of some interest to geologists, and I trust may lead to some explanation whence such vast quantities are derived.

To commence with the Old Sulphur Well—the central well with which the History of Harrogate has been, and will always be indissolubly connected—and the other springs in the cellars of the Royal Pump Room, these eight wells yield 240,000 galls. per annum.

In the Bog-Field are 21 sulphur and 14 chalybeate wells; attached to the Victoria Baths are the Old Crescent Well, Leamington Spa, and five other mineral waters; contiguous to the Royal Pump Room is the Well of Litigation, approaching in strength the Old Sulphur Well, and which, fifty years ago, was the cause of a law-suit, and the perpetration of a pun by the presiding judge about "letting well alone."

This litigation produced one excellent result in bringing to bear upon the knotty problems connected with our spas, the most eminent scientific authorities of that day, both geological and chemical: Dr.

Smith, the father of English geology, Phillips, Daniell, Dalton, Clanny, the inventor of a safety-lamp, West, Hunter, Sopwith, were all engaged, and even Faraday was invited to join in the fray, which, however, he declined.

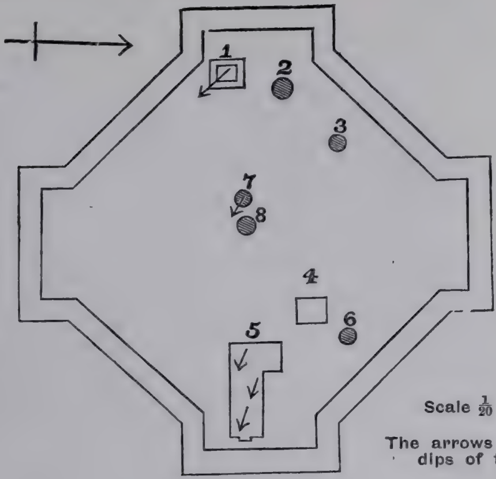
In the Montpellier Gardens and adjoining it, are nine sulphur wells, one of which is the strong sulphur, rivaling the Old Well in strength of salines, and exceeding it in gases. In the same gardens is the famed Kissingen Well of which more will be said further on. In the Concert Room grounds is the unique Chloride of Iron Spa and Carbonate of Iron Well. The Old Spa and Tewit Well complete the list of waters now utilized.

Taking the yields and strengths of these wells which are known, I think I am rather understating in assuming that the total yield of solid constituents by all our mineral waters is not less than 100 tons per annum, which if formed into a cylindrical column ten feet in diameter, would rise to a height of seventy feet, or in other words, it would form two obelesks each larger than Cleopatra's Needle by nearly 200 cubic feet.

The Sulphur waters in former times furnished a branch of industry which has long since fallen into disuse; to quote the words of the old chronicle which dates back 230 years (1656), "the inhabitants near the wells, yearly, when the company is gone boil great quantities of the Water, and procure Salt from it, which is sold in the Country and sent up to *London*."

Another point of interest is to what a comparatively small area our mineral waters are confined. A space measuring 760 yards by 180 yards includes all except the weak chalybeate waters on the Stray; while within the space inclosed by the walls of the Old Sulphur Well Pump Room, measuring about 10 yards square, 13 tons of solids per annum are discharged by the eight springs situated in this circumscribed space; and these, though in such close proximity to each other, differ not only in strength but also in constituents; within five feet of the Old Sulphur Well is another only two thirds the strength; and eight feet from this latter, is another sulphur water only one third the strength of the Old Well in solid constituents and sulphur compounds.

GROUND PLAN OF CELLARS IN THE ROYAL PUMP ROOM.



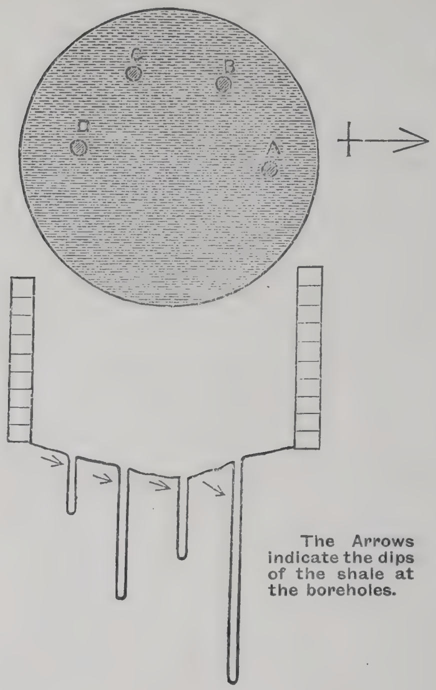
Scale $\frac{1}{20}$ in. to ft.

The arrows indicate the dips of the shale.

Date. Dec. 1883		TOTAL SOLIDS. Grains per gall.
	No. 1 OLD SULPHUR WELL	1037.75
	„ 2 NEW SULPHUR WELL	610.40
	„ 3	353.15
	„ 4	1001.70
	„ 5 TANK SPRINGS A	844.90
	B	851.20
	C	1021.30
	„ 6	873.25
	„ 7-8	996.10

I have met with almost as great variations in a much smaller space than above, the accompanying sketch represents the bottom of the Kissengen Well; it is three feet in diameter, and lined with bricks resting on the exposed shale; there are four bore-holes about twelve inches apart of different depths, as represented in the lower sketch: while **A** yields a water containing 682 grains of solids per gallon, **B** yields one containing only 478, and **C** which is ten inches from **B**, produces a water containing 929 grains; **D** is the weakest of all, containing only 428 grains. A remarkable fact is the small quantity of carbonate of iron in all these waters issuing from the boreholes, not exceeding from one third to three quarters of a grain; another point of interest is the comparatively large quantity of barium present in the water from the borehole marked **C**.

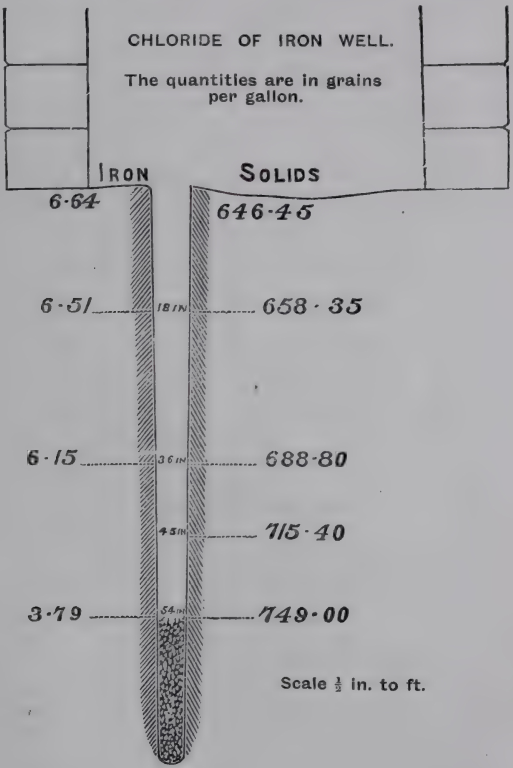
THE KISSENGEN WELL.



The Arrows indicate the dips of the shale at the boreholes.

	D	C	B	A	
RESIDUE	428.4	929.6	478.1	682.5	GRAINS PER GALLON.
FERROUS CARBONATE ...	.76	.58	.30	.49	„ „
BARIUM CARBONATE ...	2.9	9.2	4.0	6.5	„ „
CHLORINE	247.3	559.8	288.9	401.6	„ „
DEPTH	6 in.	15½ in.	9 in.	25½ in.	

There is another curious fact which has recently come under my observation, and which I think may be of considerable interest: that different strengths of water according to the depth exist simultaneously in the borehole of a well, although discharging its water at the rate of from two to three gallons per hour. Samples of water which I took from the borehole of the Chloride of Iron Well, which is six feet deep, and where the stratum of shale is nearly vertical, show this interesting, and to myself unexpected, fact; the sketch represents at the various depths indicated the proportion of solid constituents, also the iron present in the water, the difference in the amount of solids as it arrives at the surface of the borehole, and as I found it 4½ft. down is more than 100 grains, while on the other hand, the iron increases to nearly double as it approaches the surface.



The yield which I timed as the water rose from a depth of 18 inches to 6 inches, is 3.6 gallons per hour, while on another occasion. I gauged it from a depth of 8 inches to 4 inches, the yield was only at the rate of 2 gallons per hour.

These differences of strength increasing with the depth, would seem to point out that the water according to its density exists in the stratum of shale, and has a lateral motion which is only diverted upwards when it approaches the borehole or fissure, if it rises through one.

These different densities are not the result of an undisturbed condition extending over a long period of time, but are quite recently produced, as the samples were taken 36 hours after the borehole had been well stirred up in clearing it of accumulated mud.

The practical applications of these facts have a significance to Harrogate and its Spas, which is not of the same import elsewhere, unless situated in the region of mineral waters.

Suppose a well to be sunk in a part of Harrogate, to a depth of 18 to 20ft., where the conditions to be spoken of exist, the alluvial deposit will first be penetrated, then perhaps sand, afterwards yellow clay, then a blue or almost black clay is reached, after which is the black shiver or shale, the upper part finely laminated, and which, as the excavation proceeds, becomes harder and of a more rock-like character almost like slate, by this time sulphur water will probably be reached.

The characteristics of the water met with in these proceedings will be found as variable as the strata. There is first the surface water containing carbonate of iron in solution to a more or less degree; when the blue clay is penetrated a weak saline water charged with iron either as carbonate or in some other combination makes its appearance; and as the excavation continues the water becomes more saline and less chalybeate; eventually a zone is touched of strong saline water containing only traces of iron; and proceeding, these traces disappear, and a saline sulphur water is reached. Of course these differences are gradual.

It is obvious that any excavation in the vicinity of such a well as I have described, if it allows the water bearing strata to discharge into a drain, culvert, or any other continuous outlet, will permanently let down these stratified waters; to increase the number of wells will also have a sensible effect upon the first well sunk, unless there is some peculiar geological formation which prevents this occurring, even the frequent emptying of a well will in some instances temporarily reduce the strength of a water, which, however, only requires to be let alone to restore it to its normal condition. These remarks to many will be very trite, but they are none the less important in their bearing upon our valuable Spas.

In considering the large amount of solid constituents discharged by the various springs, it is to be expected that variations in their composition must occur. To refer to the Old Sulphur Well, as pointed out by Dr. Thorpe, "the general composition of the water has experienced no very material alteration during the past 100 years, but that certain well-marked changes have occurred during that time." I propose to refer to what has especially come under my own observation.

In 1866 Barium was first discovered as a constituent in the water of the Old Sulphur Well, while twelve years previous, it was stated by Dr. Hofmann to be absent, and he finds a constituent present incompatible with the presence of salts of barium, viz:—sulphate of lime. Dr. Scudamore in 1820, and Dr. Garnett in 1791, also give this as a constituent.

In the Royal Institution Journal, 1823, Vol. 15, page 82, I have taken the following remarks by Mr. West, who had a large acquaintance with the Harrogate Spas. It is with reference to an analysis of the water of the Old Sulphur Well. "The most careful examinations with tests prepared by different chemists, discovered not the least trace of sulphuric acid in any combination. I was so surprised to find this, that I hesitated to admit the inference from my first trials, but with the salts of barytes prepared by other chemists, as well as with my own, not the slightest cloud was produced."

Dr. Murray, a physician practising at Scarborough, fifty years ago, has left on record the following observations, his letter is dated 16th August. 1836. "In the 29th number of the Royal Institution Journal, being that for April, 1823, there is an ample detail of the experiments of Mr. West and myself upon Thackwray's Well, and that belonging to the public, marked No. 1 (Old Sulphur Well), and there you will observe a particular notice by Mr. West of the singular loss of the combinations of the sulphuric acid." Mr. West adds, "Should the observations of any future chemist agree with mine on this point, we must suppose, considering the respectability of those who state the existence of sulphates in the water of the Old Well (Drs. Scudamore and Garnett), this to be an established case of a mineral water varying so much as at times to exhibit a notable quantity of a substance; at other periods wholly absent."

"Allow me to add," says Dr. Murray, "that *the same tests* and the *same appliances* showed the presence of sulphates in the water from the *same spring*, in 1806, which did not do so in 1823, by the same chemist, who now remains, yours most faithfully, P. Murray."

How near these chemists of former times were in discovering the presence of barium, the existence of which is to be inferred by the absence of sulphates.

The new sulphur well in the Royal Pump Room, designated No. 2, is stated by Mr. West, in 1835, to contain 11 grains sulphate soda in a gallon of the water; in 1869 Drs. W. A. Miller and Muspratt give barium as a constituent; this is now absent, and sulphate of lime to the extent of 15.89 grains per gallon is present; this well is within 5 feet of the Old Sulphur Well. In 1866 I found 3.54 grains Barium Carbonate in a gallon of the water from the Magnesia Well; during the past winter I noticed this constituent had disappeared, and a sulphate was present; quite recently I find the barium has re-appeared.

But a still more rapid change of these constituents has come under my notice, in December last year, in the making of a shallow trench in the cellar of the Royal Pump Room, for laying a pipe to take the overflow of one of the wells, a spring of sulphur water was observed, this was utilized, at first the water showed with the usual tests abundant evidence of the presence of a sulphate, a month later the sulphate had disappeared and barium had taken its place.

The presence of barium militates against the usually accepted theory, as stated even in the most recent text books of geology, viz:—that the sulphiding of the waters is produced by the decomposition of sulphates in contact with organic matter. I infer that the presence of sulphates in a sulphur water is regarded as conclusive evidence of the correctness of this theory, but when there are no sulphates, and barium and strontium, constituents of the primitive rocks are present, some more satisfactory explanation seems to be required.

Lime sulphate must of necessity enter largely into the composition of the superficial stratum in the neighbourhood of our sulphur waters, owing to the decomposition of the sulphur precipitated from the overflowing water by exposure to the atmosphere. It would appear, therefore, that as our waters approach the surface, they are liable to admixture with water charged with lime sulphate percolating downwards, and if a preponderance of sulphate is present, the barium may be expected to disappear from solution, but the usual changes observable in adding solutions of these two salts do not occur with anything like such rapidity as may be observed in a laboratory.

When the water of the Old Sulphur Well containing barium carbonate in the proportion of 6.173 grains per gallon, and of the New Sulphur Well water containing 15.89 grains of lime sulphate per gallon are mixed together no precipitation occurs within 24 hours, and the water will remain bright for some time; after a week or so the usual double decomposition takes place, but the precipitate assumes a different character to what is usually observed, it is semi-crystalline. Previous to this interchange, the water is in the anomalous condition of giving reactions with solutions of either salts of sulphuric acid or barium.

I venture to suggest that this inchoate or nascent condition may be favourable for the deposition of the insoluble salt, and explains the occurrence of the barium sulphate mentioned by Dr Thorpe, as existing in considerable quantity in the cracks and fissures of the sandstone in this district.*

As a counterpart to the instance I have given with regard to the Harrogate Spas of the delayed action when conflicting constituents are brought together, I now furnish a case where an unexpected deposit occurs in one of the mineral waters.

---

* In the proceedings of the Newcastle-on-Tyne Chemical Society, some years since, there is an account of a deposit which had formed in a water box in the shaft of a coal-pit in that locality. The box had been filled up until its sectional area was reduced from 7½ square inches to less than half a square inch; on submitting this deposit to analysis, it was found to consist of 90 per cent. barium sulphate, 8 per cent. strontium sulphate, the rest calcium sulphate, silica, alumina, and ferric oxide. The water on analysis was found to contain small quantities of ferric oxide, silica, alumina, and sulphuric acid, a moderately large quantity of calcium carbonate, and a large amount of potassium and sodium chlorides; total solids about 800 grains per gallon. The analyst, Mr. J. T. Dunn, states that although about two gallons of the water was evaporated, no trace of barium or strontium could be found. This furnishes another instance of the disappearance of constituents which must have existed in considerable quantities in the water to have formed such a large deposit.

The Alexandra Chalybeate water which springs in the Bog-Field, is brought down to the Royal Pump Room in ebonite pipes of half-inch bore; in the course of two or three years the pipe becomes completely blocked up by a crystalline deposit, which on examination I find to consist principally of lime sulphate, with small quantities of lime carbonate and ferric oxide. An analysis I made of this water in the snmmer of 1870, exhibits the presence of a little over 9 grains of lime sulphate in the gallon. I am not aware of the conditions which cause the deposition, the water springs freely at the rate of something like 600 gallons in the 24 hours, it runs without intermission through the pipe, which is of narrow bore, and consequently with considerable rapidity, such a small quantity of lime sulphate would naturally be expected to remain in solution.

In conclusion, these few remarks are mere indications of the Mineral Wealth of Harrogate, the Spas may be regarded as a mine only partially explored. There is work enough for the geologist and chemist for many years to come, such questions as, how do the waters acquire their sulphur constituents, and are they always present in the same combination; is the formation of chloride of iron an original constituent like sodium chloride, or produced by some process of decomposition; and other problems might be mentioned which await solution.

ANALYSIS OF THE KISSENGEN SALINE CHALYBEATE WATER, 1883, AS COMPARED WITH ANALYSES IN 1845, 1854, 1867, AND 1879. BY R. LLOYD WHITELEY, ESQ., STUDENT IN THE YORKSHIRE COLLEGE.

In the paper which I have the honour to read before this Society there is little to relate which is interesting, except in so far as it may throw a little more light on the character and composition of the well-known Kissengen Spring, at Harrogate.

I collected the water from which my results are taken, in June, 1883. The day was a fine one, the temperature of the air being 16°C (61°F), that of the water being 13°C (55½°F). It was decidedly alkaline in reaction, with strong salty taste, perfectly clear, sparkling with small bubbles of gas, and of Sp. G. of 1·00428. The water, before being sampled, was well pumped out of the pipes so that the sample collected might fairly be considered a good one. The results of the analysis made of this water are (with the exception of constituents present in very minute quantities) the means of at least 2 concordant analyses. Strontium and Lithium were undoubtedly present in the water, as I had a very distinct spectroscopic test; but the quantity was too minute for estimation. The results showing the amount of elements and acid radicles present in the water in grains to the gallon, you will see on the smaller diagram before you. On the other diagram you see the compounds which these elements form expressed both in grains per gallon and parts per 1,000. Referring once again to the smaller diagram, you have a table which shows this analysis compared with those which have been made before; and this comparison brings out some rather noticeable features, showing most clearly to what variations its composition is subject.

When Mr. Attfield analysed this water, in 1879, he says, "these analyses show that the water has not materially varied within about a quarter of a century." And yet, not only had the water then 12% less solid matter than in 1867, but also the amount of two or three of the principal constituents was very much different. In fact, the ratio of some of the constituents to the total solid matter is very much different to what it had been in 1854 or 1867.

He found considerably more (in proportion to the total solids) Potassium, Iron and Silica than had ever previously been found; whilst on the other hand, he shows a large decrease in the amount of Calcium, Barium, and Strontium.

My analysis differs also, not only in total amount (being 60% less than in 1867), but also in the ratio of its constituents from any previous analysis.

The Potassium has returned to its former level; the Iron, whilst less than in 1879, is more than before; of Silica there is twice as much as in 1879, or eight times what it was in 1854; whilst the Chlorine is lower than ever.

I have also been able accurately to estimate the Bromine, though unable to find a trace of Iodine.

You will please to bear in mind that in these comparisons I have been dealing with differences always in proportion to the total solid matter, whilst the figures in the table give yon the *real* difference in parts per gallon.

To place these ratios more clearly:—

	1867.	1879.	1883.	
K	·36°/₀	1·28°/₀	·43°/₀	°/₀ of total solids.
Fe	·17°/₀	·52°/₀	·39°/₀	
Cl	60·4 °/₀	60·00°/₀	54·7 °/₀	
Ca	7·0 °/₀	4·00°/₀	4·9 °/₀	
Ca to Cl.	7 to 60	4 to 60	5 to 55	

If I am asked for the reason of these strange variations, I can only give an hypothetical answer.

Mr. McNeill (the present lessee of the gardens, who has helped me in these investigations by every means in his power) says the water often varies considerably on two consecutive days, and yet in an opposite manner, for example:—one day at 7 o'clock it is weak, and at 8 o'clock is strong; and perhaps next day it is weak at 8 o'clock and strong at 7 o'clock. And through him I was able to see a report of Mr. Davis's about this water, to which I am kindly allowed to refer.

On examining the well in March, 1880, he found no less than five different sources of water, all of which combine to form the Kissengen water; the strongest of these had 930 grs. per gallon total solids, whilst the weakest had only 191 grs. with specific gravities of 1·0098 and 1·0018 respectively. Also the water taken from different depths of the well in which it accumulates, differs considerably in strength.

Taking these facts into consideration, it seems to me that we cannot wonder at the differences in the analyses, as so much seems to depend not only on the amount of water in the well, but also on the relative rate at which these various springs are flowing at the time.

GRAINS PER GALLON.

(Smaller Diagram).

	1845.	1854.	1866.	1867.	1879.	1883.
	West.	Hoffmann.	Davis.	Muspratt.	Attfield.	Whiteley.
K.		5·959		3·620	11·216	1·736
Na.	259·810	258·244		275·410	265·227	122·328
Li.					trace	trace
NH_4		trace			·148	·077
Ba.			5·324	4·192	1·785	·914
Sr.			1·678	trace	·490	trace
Ca.	62·955	57·397		69·107	35·016	20·366
Mg.	8·665	20·944		21·197	16·520	7·733
Fe.	2·172	1·347		1·795	4·630	1·568
Mn.		trace		trace		·042
SiO_2		·947		·438	3·570	3·353
SO_4	6·693				·210	
CO_3	5·950	31·297		16·012	10·926	22·826
Cl.	529·154	532·400		599·260	525·005	220·602
Br.		trace			trace	·619
I.		trace			trace	
PO_4						Doubtful trace
TOTAL...	875·399	908·535		991·031	874·740	402·974

NAMES OF COMPOUNDS PRESENT.

	Grains per Gallon.	*Parts per 1,000.*
NaCl.	303·975	4·324
KCl.	3·304	·047
NH_4Cl.	·210	·003
$CaCl_2$	41·266	·587
$MgCl_2$	10·964	·156
$MgBr_2$	·703	·010
$CaCo_3$	13·708	·195
$BaCO_3$	1·336	·019
$MgCO_3$	17·434	·248
$FeCO_3$	3·234	·046

NAMES OF COMPOUNDS PRESENT—(CONTINUED).

$MnCO_3$	·091	·001
Na^2SiO_3	6·749	·096
TOTAL	402·974	5·732

Since writing this paper I have been able, through the help of a fellow-student (Mr. Gamble), to make three estimations in water collected on April 18th, 1884, showing

Total Solids	830·62	Grains per Gallon.
Chlorine	488·00	
Iron	1·47	

being in total solid matter very similar to when analysed in 1879.

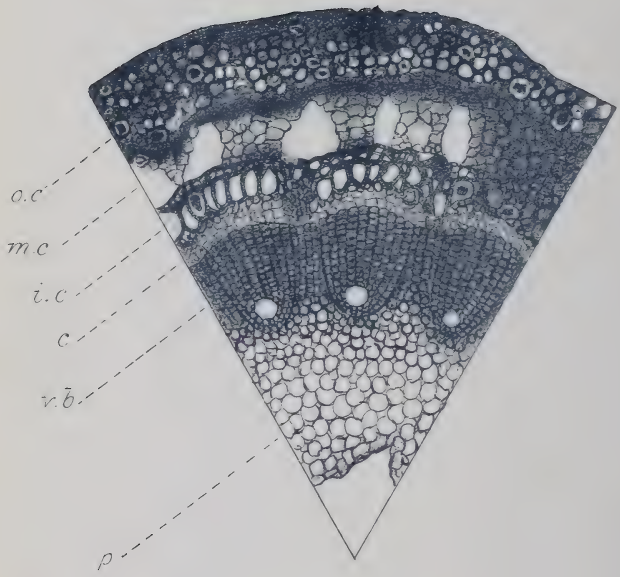
CONTRIBUTIONS TO THE FOSSIL FLORA OF HALIFAX. PART IV.

BY THOMAS HICK, B.A., B.Sc., AND WM. CASH, F.G.S.

SINCE our last communication on the Fossil Flora of Halifax was read before this Society, the work of investigation has gone on as regularly as circumstances would permit, and results of greater or less value have been obtained. These results have been summarised in two reports, which in conjunction with Prof. Williamson, F.R.S., we have presented to the British Association. As these reports show, few striking novelties have been unearthed during the last two or three years, the specimens collected having added but few forms that were not previously known. Nevertheless the accumulation of specimens, even of well-known plants, has not been altogether without value, inasmuch as we have thereby obtained a clearer insight into the structure and affinities of these than we previously possessed. In this direction then, if in no other, some advances of importance have been made, and it is the object of this paper to refer to one or two points in connection therewith.

Calamites.

Of the numerous genera of fossil plants whose organization has been made out with any degree of satisfaction, one of the best known is that of *Calamites.* Nevertheless, owing to the fact that few specimens have been met with in which the cortical tissues are



PORTION OF TRANSVERSE SECTION OF STEM OF CALAMITES.

p — *Pith*
v. b. — *Vascular bundles*
c — *Cambium*
i. c — *Inner cortical layer*
m. c. — *Middle cortical layer*
o. c. — *Outer cortical layer*

A. Mageon & Sons

preserved, our knowledge of this part of the stem of a Calamite is still very imperfect.

Recently, however, a specimen has come into our hands which presents a more perfect view of the transverse section of a Calamite than any we have previously met with. The bark is especially good, and we only regret that we have not an equally complete section in the longitudinal direction. The following description will convey some idea of its appearance.

The Pith (Pl. XIX., p.) is somewhat elliptical in form, with a greater diameter of ·091in., and a less of ·084in. It is composed of ordinary-looking parenchyma, whose elements are rounded or polygonal in shape, and are larger, and have thinner walls towards the centre than at the periphery. The actual centre is wanting, the tissue having disappeared leaving a lozenge-shaped empty space. This, however is not more than 0·07in. in length by 0·04in. in breadth, so that a large portion of the pith is still intact.

The Vascular Bundles (Pl. 1, v.b.). Surrounding the pith are 17 wedge-shaped masses of vascular tissue, each of which carries at the apex a well-marked internodal canal. In the transverse section the vessels appear of a uniform size, somewhat square in shape, and arranged in radial rows. Two or three rows of smaller vessels separate the internodal canals from the pith. The spaces between the bundles that constitute the primary medullary rays, are comparatively broad and short, the cellular elements soon giving place to radial rows of what appear to be vessels quite similar to those of the bundles. If this be their nature, it is a warrantable inference that they originate in an interfascicular cambium, which uniting the cambium of the separate bundles, gives rise to a complete cambium zone.

The Cambium Zone (Pl. 1, c.) is very thin—not more than three or four cells thick—and has for the most part undergone some compression. Its cellular constituents have thin walls, but the radial arrangement is not so distinct as in the cambium of a Dicotyledon. Whether this is the natural condition, or due to external agencies, we have no means of determining.

*The Cortex.**—Outside the cambium zone is the Cortex, which for descriptive purposes may be regarded as consisting of three portions.

1. *The inner Cortical layer* (Pl. 1, i.c.)—This layer hardly seems to be quite continuous round the stem, but this is obviously due to slight imperfections in the specimen. In those parts where it is best preserved, its appearrance strongly resembles that of the transverse section of the xylem of a fern, presenting a central series of large thick-walled elements (vessels ?), enclosed both on the outside and on the inside by one or two rows of smaller but similar thick-walled elements. At one or two points this layer seems to dip down through the cambium zone to the vascular zone, and thus divide the cambium into separate and distinct portions. The specimen does not show whether such a dipping down obtained all round the stem, and this point is not determinable by our other sections. As the dippings down that are present are opposite the intervals *between* the vascular bundles, the portions of the cambium they enclose are *opposite* the bundles themselves. If other specimens should enable it to be demonstrated that such an arrangement is characteristic of *Calamites*, the different portions of the inner cortex would occupy the same positions with respect to the vascular bundles, as the phloëm masses of Dicotyledonous stems, and might be homologous with them.

Some of the large elements of this layer, contain a black carbonaceous mass, and others a complete or incomplete ring of similar material. Whether this is to be regarded as the fossilised representative of resinous, protoplasmic or other substances which these elements contained we cannot venture to say.

2. *The middle Cortical layer.* (Pl. 1, m.c.)—This consists of thin-walled tissue with a peculiar arrangement. The cells of which it appears to be chiefly composed, are grouped into radial masses, which broaden towards the periphery, something like the medullary rays of *Tilia*. Between these struts of cells, there are larger or

---

* The term *Cortex* is here used provisionally for the whole of the tissues that lie outside the Cambium, which produces the successive layers of Vascular Tissue. This is not strictly in accordance with the practise of botanists in describing recent plants, but the term seems much more appropriate than *Bark*, by which these tissues of fossil plants are frequently designated.

smaller spaces which appear to resemble air canals. On this point, however, our section is not clear, and we make this statement under cover of a reservation. Sometimes the cortex separates through this layer, leaving the inner cortical layer and the cambium behind, as is shown in other specimens in our possession.

3. *The outer Cortical layer* (Pl. 1, o.c.) consists of elements more or less rounded in transverse section, with thicker walls, and in many cases, black carbonaceous contents. They are not uniform in size, some being very much larger than the rest. Their exact histological nature can scarcely be said to be absolutely established, but there is some evidence that they are prosenchymatous cells or fibres. The best preserved and clearest parts of this portion of the section show few or no indications of the "hypodermal zone of specialised bundles" of apparently prosenchymatous tissue described by Prof. Williamson.*

Other specimens in our possession, though agreeing with the above description in one or more particulars, present differences which ought to be noted. In some of these, there is little or no distinction between the inner and middle cortical layers; and the large vessel-like elements of the former are less regularly arranged. The cambium, as might be expected, is often so compressed as to be almost obliterated; while in other cases, it, as well as the delicate cells between the larger elements of the inner cortex, is a confused mass whose structure it is not easy to determine.

A comparison of the above description with a transverse section of an *Equisetum—E. arvense* for example—will be found both interesting and suggestive. The pith and the vascular bundles of the fossil are evidently homologous with the parts, similarly named, of the recent plant. But the comparison gives support to the further view, that what we have termed the *middle* cortical layer of the fossil, with its presumed air canals, corresponds more or less closely with the *inner* cortex of the *Equisetum*, in which air canals are also present. In that case, the *inner* cortical layer of the fossil must be regarded as part of the axial tissues.

---

* "Organization of the Fossil Plants of the Coal Measures." Part XII., p. 465.

Additional well-preserved specimens will be required to confirm the homologies here suggested, before they can be accepted without reservation; but it may be pointed out that the undoubted affinities of *Calamites* with *Equisetum* are all in their favour. Should they be eventually fully established, what we have described as the inner cortical layer, will have to be regarded as phloëm belonging to the vascular bundles. The cortex will then consist of the tissues described as making up the middle and outer cortical layers, and will be brought into a closer agreement with the cortex of *Equisetum.*

We append the following particulars respecting the dimensions of the specimen:

Total diameter =0·2 inch, nearly.
Longer diameter of pith = 0·091 inch.
Breadth of vascular zone = 0·0175 inch.
Breadth of cortex = 0·0315 inch.
Large elements of inner cortical layer = 0·00425 × ·0003.

Myriophylloides Williamsoni.

In the vol. VII., p. 400 of the Transactions of this Society, we published a detailed description of a remarkable fossil stem or branch, for which we proposed the name of *Myriophylloides Williamsoni.* Our description created no little interest amongst the few investigators who are working at palæophytology, and additional examples of the fossil were soon brought to light by the praiseworthy efforts of Messrs. Binns and Spencer. Mr. Spencer's specimens led him to the conclusion that our *Myriophylloides* was the early corticated condition of a plant previously described as *Astromyelon*; and Prof. Williamson having gone over the whole series of specimens, both new and old, has adopted Mr. Spencer's view. The grounds on which he has done so, are fully set forth in part XII. of his memoirs: "On the organization of the Fossil Plants of the Coal Measures," which contains also descriptions and figures of the more demonstrative specimens. This most interesting and valuable contribution to our knowledge of fossil plants, we have studied with great care, and by the light of the new facts it contains, have gone over again our original description of *Myriophylloides.* It is due both to ourselves and to the members of this Society, that we should state, as briefly as possible, the position in which we find ourselves.

As regards the description of the fossil, it is a source of some satisfaction to us, that in no respect have we found it necessary to correct or modify what was first written. The additional specimens, so far as they are undoubtedly the same plant as the original one, simply reproduce, illustrate, and give point to the statements we originally made. As to the identity of the plant with *Astromyelon*, our present judgment is, that such an identity is not yet established with the certainty that an adherence to scientific logic should demand.

In the account of *Myriophylloides* already referred to, we wrote as follows:—

"It consists of a central pith, surrounded by a number of slightly wedge-shaped masses of tissue, which are either of a fibro-vascular or of a wholly vascular character. Outside these masses of tissue or bundles, as we may term them, is a cambium ring, followed by a comparatively thick cortex. This is composed, in a great measure, of radiating plates composed of cells, with large intervening air cavities, similar to those met with in recent aquatic plants. The cellular plates do not anastomose, so that the air cavities are continuous from the central axis to the peripheral portion of the stem, which is composed of a few layers of somewhat rounded cells."

The peculiarity of the cortical structures we regarded as one of the distinctive features of the plant, and one that had not been previously met with. At the same time, we noted the fact that the vessels of the vascular tissue were of the barred and dotted types, and that they appeared to be intermixed with elongated cells of a more fibrous character, whose walls were plain.

In Prof. Williamson's Memoir already referred to, the identity of *Myriophylloides* and *Astromyelon* appears to be chiefly based upon a transverse section of a specimen of the latter plant, in which, what is very unusual, a part of the cortex is preserved. In this fragment of the cortex, there are a few cellular filaments, which certainly resemble those met with in similar sections of *Myriophylloides*, and which may be transverse sections of radiating cellular plates. Speaking of this section, Prof. Williamson says:—"The identity of the plant with the *Myriophylloides* of Cash and Hick, is shown by the retention of a small portion of the cortex. The innermost layer is imperfectly retained, but the radiating cellular laminæ are sufficiently distinct, terminating in the outer layer of cortical cells."[*]

Now we venture to think that the organization of the cortex alone is not sufficient to settle the identity of the plants in question. Modern botanists are well aware that in cortical structure such recent aquatic forms as *Marsilea*, *Potamogeton*, *Utricularia*, *Hippuris*, *Hottonia, and Myriophyllum*, have the closest resemblance to one another, and yet for the most part, they belong to widely separated Natural Orders, and some of them to quite different classes. Hence it is obvious that although *Astromyelon* and *Myriophylloides* may have a very similar cortical structure, it by no means follows that they have close affinities and much less that they are identical.

Besides this, the axial structure of *Astromyelon*, which is its leading feature, as hitherto known, bears by no means a close resemblance to that of *Myriophylloides*. Amongst the chief characteristics of the former plant, are "the distinct outline of peculiar form of the conspicuous vascular wedges constituting the exogenous zone, and the relations of these wedges to the large medulla which that zone enclosed."[†] In *Myriophylloides*, so far as specimens in our possession go, and so far as those described by Prof. Williamson show, these characters are altogether absent.

Further, the specimen of *Astromyelon* chiefly relied on by Prof. Williamson is very imperfect, only "a small portion of the cortex" being preserved.

This of itself seems to us sufficient to induce a suspension of judgment until better preserved specimens shall show whether the cortical plates and air canals had the same arrangement as we described in *Myriophylloides*.

Whatever may be the case then, in the near or remote future, we can scarcely regard the identity of these two plants, as at present fully established. The interest taken in them will, however, continue to exert a stimulating influence upon all *Palæophytologists*, so that we may fairly anticipate more conclusive evidence at no distant date.

Apart from the question of affinities, little can be said of *Myrio-*

---

[*] Loc. cit. p. 460.

[†] Williamson's Memoir, part XII., p. 460.

phylloides in addition to what we have already published. In some of the more recently acquired examples however, which are apparently younger than the orginal form, the pith is much reduced in relative size, while in others it seems to be altogether absent. In these last, the vascular wedges appear to meet in the centre of the axis, but they still retain their radial arrangement, and have evidently been developed centrifugally.

A more important point, perhaps, than the diminution or absence of the pith, is the state of the cortex in the earlier stages of developement. From some of our younger specimens it would seem that at first the cortex forms a continuous mass of thin-walled parenchyma, in which neither air cavities nor radiating plates have as yet been differentiated. The specimens are not decisive as to the mode in which these are afterwards formed, but they suggest the idea that the process is the same as that which obtains in recent aquatic plants. In these, the air cavities arise schizogenously, that is, by the splitting of the cellulose lamellæ which form the walls of the cells, as may be readily seen in young peduncles of *Nuphar*, and the stems of the aquatic plants already mentioned. In the phenomena presented by the earlier developmental stages then, we have a confirmation of the justness of our original views, so far as they had reference to the aquatic nature of *Myriophylloides*.

FURTHER NOTES ON NEW SPECIES, AND OTHER YORKSHIRE CARBONIFEROUS FOSSIL POLYZOA DESCRIBED BY PROF. JOHN PHILLIPS. BY GEORGE ROBERT VINE.

THE Genus *Calamopora* was founded by Dr. August Goldfuss* for the reception of species that had been previously described by authors as *Tubipora*, and by Lamarck as *Favosites* and *Alveolites*. The definition of the Genus is very simple, but by no means satisfactory, as it is quite clear, that even by the author himself, many diverse forms were placed together. Some of the species described by Goldfuss were ramose, others massive; and because many of the species from the Devonian and Silurian formations, had some apparent likeness to Carboniferous fossils found in Yorkshire, Phillips was induced to adopt the Genus *Calamopora*, for the placement of the Yorkshire fossils also.

---

* Petrefracta Germanæ.

In the Geology of Yorkshire three species are described, but I wish now to direct attention to one of these in particular.

CALAMOPORA, Goldfuss.

Geo. of Yorkshire, Ed., 1836.—*Stenopora* and *Chaetetes* (Phill). "Found mostly in laminar limestone cherts and shales. From the Brough Limestone to the Upper Millstone Grit." (op. cit.)

CALAMOPORA TUMIDA, Phillips.

Geo. Yorksh., Ed., 1836, Pl. I., Figs. 49, 50, 51 only.

"Irregularly ramified and swollen, formed of concentric layers of prismatic cells, contracted to a small opening at the surface.

Localities—Harrogate, Greenhow-hill. Brough, Kirkby Lonsdale, Middleton (Florence Court: Arran, Phill.)" (op. cit.)

This brief description of *C. tumida* has caused no end of bother to Palæntologists whenever they have attempted to identify species in other than Yorkshire strata. In my Richmond and Hurst material I have several specimens of what I believe to be true *C. tumida*, Phillips; and because the specimens differ in many respects from others with which they have been associated, I make no apology for adding the following notes to the literature of the species.

MONTICULIPORA TUMIDA, Phillips.

1836. *Calamopora tumida*, Phill., Geo. Yorks., Vol. ii., pl. I., figs. 49, 57.
1843. *Favosites tumida*, Portlock, Geo. Rep., p. 326, pl. XXII., fig. 4.
1844. ,, ,, M‘Coy, Synop. Carb. Foss. Ireland, p. 193.
1850. *Stenopora tumida*, M·Coy, Brit. Pal. Foss., p. 82.
1852. *Chætetes tumidus*, M. Edw. & Haime, Mono. Brit. Foss. Caor.
1872. *Monticulipora tumida*, De Koninck (?) fide Nicholson.
1881. ,, ,, Nicholson, "Genus Monliculipora," p. 120.
1884.? *Batostomella tumida*, Ulrich, Am. Pal. Bryozon, Jour. Cin. Soc. Nat. Hist., April.

In his work on the "Genus Monticulipora," Prof. H. A. Nicholson in giving some of the above references, cites another one by R. Etheridge, jun.; but as Etheridge's species has been referred to a new Genus founded by Mr. John Young, I have left it out of the above list. The description of Nicholson's *M. tumida* is founded on specimens collected from the neighbourhood of Redesdale, Northumberland, where "the form is very abundant and well-preserved" in these Carboniferous shales. Along with the "normal type," there is another occasionally met with, and this Prof. Nicholson has described in the same work as *M. tumida*, Phill., var. *milliaria*, Nich., but the author says "in our ignorance of the complete corallum of *M. tumida*, it is impossible to assert positively that this apparently well-marked variety may not be really merely founded upon some particular *part* of the adult skeleton, as for example. the young actively growing branches."*

In a later work, "Contributions to Micro-Palæontology" † Prof. Nicholson remarks:—"It is quite clear that Phillips himself included at least two different forms under the name *Calamopora tumida.* One (Geo. Yorks., pl. I, figs, 49-51) is almost certainly the form which I have here and elsewhere regarded as *Monticulipora tumida.* Another form (op. cit. pl. I., figs 52, 56, 57) may be taken as an equal approach to certainty, to be the type which I have called *Stenopora Howsii*, Nich." This later species, however, Mr. John Young, of Glasgow, refers also to his new Genus *Tabulipora.*

In the Annals and Mag. Nat. History, 1874, is a short paper on "*Chœtetes tumidus*, Phill., by R. Etheridge, jun." At page 195 he says, "This is probably the fossil figured by Ure in his 'History of Rutherglen and East Kilbride,' pl XXII., fig. 1, and by Fleming as *Cellepora Urii.*‡ If this be so, Ure was the first to figure *Chœtetes tumidus.*"

Recently the "Millepore," of Ure, has been taken in hand by Mr. John Young, and in a paper on the subject,§ the author says, p. 155, "I have discovered what I believe to be an important internal character in the structure of the organism which Ure figured and described in 1793 as a species of "Millepore." and which will,

---

* Genus Monticulipora, pp. 123-4.

† *Ann. Mag, Nat. Hist.*, Nov. 1883, p. 294.

‡ *Brit. Animals*, 1828, p. 533.

§ *Ann. Mag. Nat. Hist.*, Sept., 1883, pp. 155, 158.

. . be the means of distinguishing it from Phillips' species. . . This new character consists of a series of thin, perforated tabulæ, that exists in the outer portion of the tubes of the larger corallites. The perforation or central opening in these tabulæ is of a roundly crescentic or reniform shape, and has a thickened edge around its margin; its diameter being one third the width of the tubes." This "perforated tabulæ" is sufficiently characteristic to distinguish the Scotch from the Yorkshire form at least, and Mr. Young has only acted consistently by naming it TABULIPORA URII, Young.*

In his writings on "American Palæozoic Bryozoa,"† Mr. E. O. Ulrich founded the Genus "*Batostomella*" as one of a numerous list of genera which he included in the Family Monticuliporidæ Nicholson. The description of the Genus is "Ramose, branches smooth, usually small; cell apertures small, interstitial cells and spiniform tubuli few to numerous; walls of tubes in the peripheral region thick, and seemingly fused together. Trenton to Carboniferous." In this Genus Mr. Ulrich (op. cit. Ap. 1884, p. 26) places Phillips species as BATOSTOMELLA TUMIDA, Phill., but as he places very near to it the Scotch form *Ceriopora interporosa*, Phill., which in many respects has a faint resemblance to *Tabulipora Urii*, Young, in all probability Mr. Ulrich refers to his Genus, not Phillips', but Ure's species.‡

This last reference I cite because Mr. Ulrich believes that the whole of the Monticuliporidæ are Bryozoa (or Polyzoa); and because I have ventured to differ from him on this particular in my fourth Brit. Associa. Report on Foss. Polyzoa, 1883, I seem to have greatly offended him (*vide* Jour. Cin. Soc. Nat. Hist., Ap., 1884). Notwithstanding this, I shall faithfully consider, in the remarks which will follow, all the moot points which he has raised in his defence of the Bryozoal nature of the Monticuliporidæ, of which family Phillips species is a member, though a very erratic one. And I do this with a still greater desire for faithfulness, because Phillips' species and the Scotch species at that time§ considered identically the same as

---

* Mr. Young says, *T. Urii*, Flem. But this is wrong.

† Cin. Soc. of Nat. Hist., Oct., 1882.

‡ Question—On the description of Mr. Etheridge, jun.?

§ Ann. Mag. Nat. Hist., 1874.

Phillips', formed one of the earliest of my studies of Palæozoic fossils; and nearly the whole of the material that I shall use in this paper have lain by me for years. As, however, it will be necessary to redescribe the whole of the Yorkshire Calamoporæ, I must be forgiven if I follow my own methods in doing so.

Genus MONTICULIPORA, D'Orb, 1850.

See Nicholson for references. "Tabulate Corals," 1879, pp. 269-70. "Genus Monticulipora," 1881. For structure and affinities see his last work, the "Genus Monticulipora."

1.—MONTICULIPORA TUMIDA, Phill.

Calamopora tumida, Geo. of Yorks., Vol. II., pl. I.

Monticulipora tumida, Nicholson: "Genus Monticulipora," p. 120 (restricted), Pl. III., Figs. 1 & 2.

Corallum dendroid, stems cylindrical or depressed; varying in thickness from one-and-a-half to two lines; occasionally tumid at varying distances. *Calices* irregularly polygonal, circular or oval; from four to five calices occupy the space of half a line. Peristome or walls of calice entire, surrounded by a number of blunt spines, which in transparent or semi-transparent sections occupy the intervals between the calices. "Monticules" and "Maculæ," occasionally developed.

Localities: Richmond and Hurst.

The above characters are drawn up from my Hurst and Richmond specimens only, but with Nicholson's description of his *M. tumida* before me. Besides that described, I have also specimens of the so-called *M. tumida*, Phill. for comparison from Redesdale: Haltwhistle, two distinct forms; Derbyshire: and from Halken in Wales. I have the Scotch forms from several horizons, but in consideration of Mr. Young's work, the whole of these are excepted. So far as the external features can be taken as guides for identification, I am not at all surprised that Phillips' *Calamopora* has been, and perhaps will continue to be, a source of bother to collectors. My special labours on the species, however, have more direct reference to the closer comparisons necessitated by the analytical methods which modern Palæontological researches demand, especially so from my own standpoint with regard to the future placement of Palæozoic Monticulipora, whether with the Tabulate Corals, or with the peculiarly "stony" Polyzoa of Mesozoic age.

For the sake of younger students who may not be able to get at the works I have referred to in this paper, I define the terms used by me in the description of typical features, &c.

1.—Corallum*: The whole of the specimen, whether large or small, ramose, massive, or encrusting.
2.—Calice or Corallites?: The superficial openings found abundantly on the surface of the Corallum.
3.—Interstitial tubules or Openings: Spaces, &c., between the Calices, occupied occasionally by smaller openings.—"Ostioles"? Phillips.
4.—Monticules: Areas on the Corallum more or less elevated above the general surface; Corallites large.
5.—Maculæ: Areas in which the Corallites are smaller than the average, level or depressed.

If I were describing species of Polyzoa the terms used would be 1, Zoarium; 2, Zoœcia (3, 4, 5). In true Polyzoa there are no structures, superficial or otherwise, at all resembling these.

Typical structures of Phillips' Yorkshire Species.

Pl. XX., Fig. 1 *(a)* Natural size of Yorkshire specimen.

I. *Walls of the Calices.*—These are variously thickened, but the general characters of the whole are similar. Taking the calice and the walls together, I find in the Yorkshire specimen the following special features. Calice slightly oval, the inner walls of which slope gently inwards towards the floor of the cup. Surrounding the thickened rim of the calice there are numerous blunt spines varying in number from nine to eighteen (Pl. XX., Fig. 1a). In this respect the character of the calice and its surroundings are similar to the Redesdale specimen figured by Nicholson (Monticulipora pl. III., fig. 1c.) (See Nicholson on the Structure of the walls of the Corallites, op. cit., p. 36, et. seq.)

II. *Interstitial tubuli.*—These also are variously shaped, and are occasionally surrounded by a similarly thickened rim as in the normal calice, and partly surrounded by spines; but from four to five only (Pl. XX., Fig 1, b^1, b^2). These interstitial tubuli are important features in the Corallum of species of Monticulipora, and we have no analagous structures in the *Zoarium* of true Polyzoa, excepting

---

* All these terms must be taken in a popular, rather than in a strictly zoological sense.

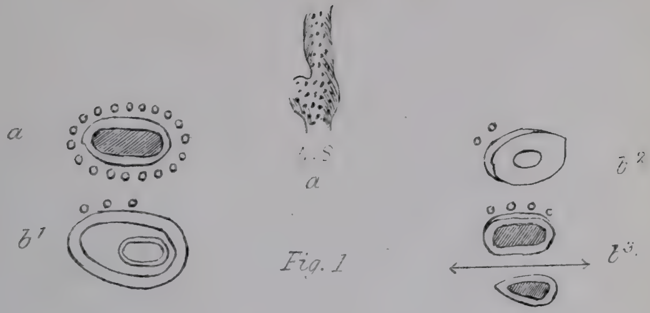


Fig. 1

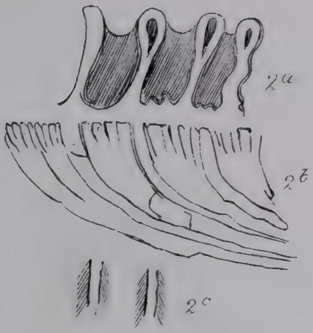


Fig. 2

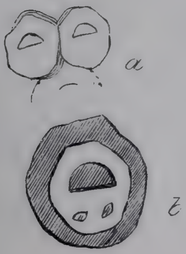


Fig. 3.

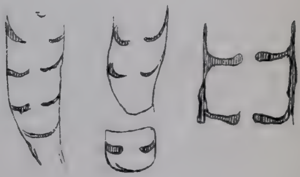


Fig 4

agson & Sons, Leeds

CARBONIFEROUS POLYZOA.

in species of *Heteropora*, at all comparably with them. It is very certain that these secondary cells have a functional value, both in *Monticutipora* and also in *Heteropora*, but what this may be we are not in a position to say. The discussion, however, of the whole subject would be a long and tedious one, and I do not think that after the masterly way in which the question has been treated by Mr. Busk, Mr. A. W. Waters, and by Prof. Nicholson,* much can be added—that is really new—to the material already in our hands. The question, however, may be much more simplified if a doubt is cast upon the Polyzoal affinity of Heteropora; for whatever may be said in its defence, there is still wanting that knowledge which can be derived from the study of the living animal only, and since species of Heteropora are recent as well as fossil, we may still hope that even this knowledge will be forthcoming. After carefully reviewing the whole of our present knowledge, Prof. Nicholson states (op. cit., p. 77), "Leaving *Heteropora* out of sight, there are no other forms of the *Polyzoa* to which *Monticulipora* makes such a near approach as to render any very close comparison necessary."

In the Monticulipora the secondary openings are, I have no doubt, young forms of "Corallites" in a primitive stage, which bud around the parent corallite; but whether the whole of these were destined to arrive at maturity is a question I cannot decide. In all probability they would not; but still, in the living state these may have been possessed of a Zooid similar in some respects to the Zooid in the older calice. In the figures of superficial or secondary calices which I have drawn (Pl. XX., Fig. 1, b^1, b^2, b^3.), there are some to which I wish to direct particular attention. It will be seen in (b^3) that the "interstitial" openings are very similar to the larger opening (Fig. 1a). These two openings—and they are characteristic of others—appear as if the walls were united; the separation indicated by the arrow appears in the section as only more transparent—no wall line can be seen. Other interstitial openings have an altogether different character. Two of these are given (Fig. 1, b^1, b^2.) Both have apparently perforated tabulæ, but they cannot be put down as such. They are very rare in the corallum, and in all probability some functional character may be indicated by them, but whatever it may be I am also unable to suggest.

---

* Genus Monticulipora, pp. 62-78.

III. *Monticules.*—The structure of the corallites at this particular part of the Corallum is peculiar. The Monticules, as I have already explained, is an area more or less elevated above the general surface, and at places where this occurs I find a double set of corallites, each set of which have different characters. In Fig. 2, 2^a I have given a drawing of several of the calices of the Monticule; while 2^b are the calices of the normal Corallum which are somewhat connected with the axial region of the Corallum; but the true structure of the walls of all these are laminar, as in 2^c. In plate III., fig. 1 of the Genus Monticulipora, Nicholson has figured a single corallite × 50 times, which show at once the general character of the corallite walls which is indicative of successive stages of growth.

None of the walls of my Yorkshire specimen show the "spini form corallite" as shown in Nicholson's fig. (pl. III., fig. 1^f), but in a section of my Redesdale species I have the same structure as figured by the author. In this the Yorkshire differs from the Redesdale and Haltwhistle specimens.

IV. *Axial region.*—In the axial—that is to say the central part of the Corallum—the tubes lie almost parallel as partly indicate (Fig. 2, 2^b, lower part) in the sketch. Here the tubes are compressed, but the walls of the separate tubes are distinct, and an interval is clearly defined between wall and wall. At varying intervals there are tabulæ, and these are complete. They are not numerous, and they do not differ greatly from the tabulæ shown in Fig. i. e. pl. III. of Monticulipora. The axial tubes, however, are far more regular than indicated in Nicholson's figure.

With these special details of the structure of Phillip's *Calamopora* before us, it will be easy to point out the differences between it and the Genus *Tabulipora*, founded by Mr. John Young; though I have a specimen of another fossil in my Hurst collection which very closely resembles, superficially, *T. Urii*, Young. It is rare, and I do not like to section it without other specimens were at hand to replace it.

In the Scotch *Tabulipora Urii*, the slightly inner portion of the calice is covered by a thin calcareous plate having a reniform opening not unlike, in some respects, the area of some species of Polyzoa. This reniform opening is what Mr. Young calls "perforated tabulæ" (Fig. 3a). A large number of fossil species, both in this country and also in America, have perforated tabulæ, but whether the other features which I am about to point out are present also I cannot say. Now that attention has been drawn to the subject, I hope more special details will be forthcoming. On the same slide of sections of Scotch specimens that give me my best evidence of perforated tabulæ, I have sections of tubes of various stages of growth in which the perforation of the tabulæ are shown at different intervals (Fig. 4). In the older tube the non-entire tabulæ are more numerous than in the younger tubes, and in every case where I can get a clear view of the area, the thin calcareous crust covers—partially—the divisional chambers. It is evident that the animal of *Tabulipora* was very different from the animal of that division of *Monticulipora* which embraces the *Calamopora* of Phillips. Years ago the peculiar structures puzzled me, they puzzle me now; but I live in hope that the dawn is approaching, and that ere long light will break upon us, not only sufficiently to show the peculiarity of, but the real nature and meaning of these palæozoic anomalies.

I have already indicated that there are several fossils which were apparently known to Phillips that still await description; these I have thought it well to incorporate with the present paper so that I may be able to finish my series of notes on the Monticuliporidæ and Polyzoa from the North Yorkshire district.

1. MONTICULIPORIDA TUMIDA, Phill., Pl. XX.

Fig. 1, A, Natural size. A^1, Normal calice surrounded by wall and 18 blunt spines (transparent sec.), b^1, b^2, b^3, interstitial tubuli referred to in text.

Fig. 2, *M. tumida*, Phill.—2^a, Corallites of the monticules; 2^b, Corallites coming to the surface immediately under the monticules, and connected with the axial region; 2^c, Laminar structure of walls. Notice the saw-like character of the base of calices in 2^a.

Fig. 3, *Tabulipora Urii*, Young, showing (a) perforated tabulæ, (b) one peculiar tabulæ with two openings below the "mouth"?

Fig 4, *T. Urii*, Young, showing the incomplete tabulæ at different stages of growth.

2. HETEROTRYPA* DELICATULA (n. sp.) Pl. XXI., fig. 1.

Corallum slender (ramose?) bearing two kinds of corallites on the surface; (a) normal; calices circular, but of rather unequal size, about five to the half line, separated from each other by a single row of (b) intermediary pores. *Monticules* feebly developed, indicated by rather larger calices, and occasionally separated from each other by at least two rows of intermediary pores.

Localities: Hurst, North Yorkshire.

One would almost imagine that these two species should be united if we went by the measurement of the superficial calices only. Both forms yield the same results—five calices to half line—but one consideration with me determines the separation. The calices of *M. tumida*, so far as a superficial examination can afford details, come up to the surface with sharp and distinct edge, and it is only when slightly rubbed that the separating spinal on intermediary openings are visible—in the present species the whole of the characters are drawn up from superficial examination. At first I was inclined to place the form as a variety of Phillips' *Ceriopora interporosa*, but M'Coy in his diagnoses of Phillips' sp. says "cells oval," and in the Scotch specimens which pass by this name, the cells are distinctly oval. It is here that the value of Mr. Ulrich's labours on the American Palæozoic Bryozoa is appreciated by me as a corrective of my own; not so much on account of his diagnoses, as on account of the careful localization of the various fossils submitted to him for examination. In one species which he names and figures as *Rhombopora crassa*, Ul.† the fig. pl. 1., f. 2, the normal cell openings with thin intermediary pores very closely resemble our own. And of this species Mr. Ulrich says (op. cit., p. 26) "Through *R. crassa*, Ul., and *Ceriopora interporosa*,‡ Phill., we can trace a resemblance to Carboniferous species of *Batostomella* (e.g. *B. tumida*, Phill.)" There is not, however, any resemblance between the present Yorkshire

---

* See Nicholson's Genus Monticulipora (Sub Genus Heterotrypa).

† Jour. Cinc. Soc. Nat. Hist., April 1884, p. 28.

‡ Judgment founded upon Scotch specimens sent to him by me.

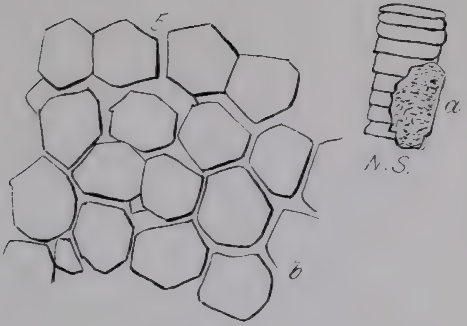


Fig 2.

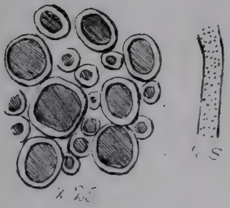


Fig. 1

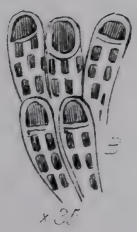


Fig. 4.

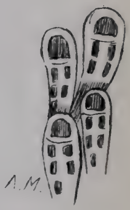


Fig. 5

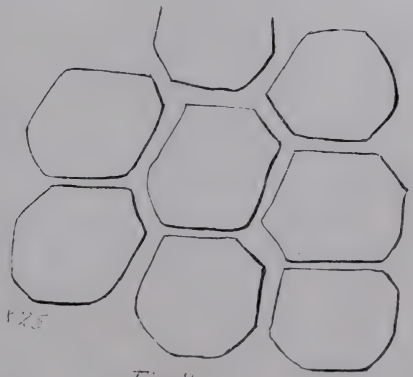


Fig. 3

A. Megson & Sons, Leeds.

CARBONIFEROUS POLYZOA.

form and the Scotch specimens. In *Vincularia Binniei*, Eth. Jun.,* there is a slight resemblance between the two fossils, but I have no evidence of "hexagonal cells" in my specimen.

I have been careful in drawing up the characters of *Heterotrypa delicatula*, for the simple reason that very little is known of the Yorkshire fossils described by me in this and other papers; and for this reason I wish to direct the attention of Yorkshire Palæontologists to the species described and figured in this paper especially.

Sub-Genus DIPLOTRYPA, Nicholson.

Pal. Tabulate Corals, p. 312—Genus Monticulpora, p. 155.

= *Stenopora* and *Chætetes* of authors.

"Corallum discoid, globose, sometimes leaf-like, with a thin basal epitheca."—Monticulipora, p. 155.

3. DIPLOTRYPA sp. var. PETROPOLITANAFORMA (n. var. ?) pl. XXI., fig. 2, a, b.

Corallum encrusting crinoid stem, with, so far as superficial examination afford me evidence, thin and structureless walls. *Corallites* of two kinds, small and large, generally hexagonal in shape. *Spiniform* corallites often present in the angles, and occasionally very conspicuous. *Monticules* well-marked, indicated by larger calicular openings.

Locality: Hurst, North Yorkshire.

I cannot say whether the present is a very abundant variety, for I have only a single specimen, and from this the above diagnosis is drawn up. If a comparison is instituted, it will be seen that the small portion of surface figured closely resemble *Diplotrypa petropolitana* Pander (Monticulipora, p. 159), but that is a free form with a basal epitheca; the present is encrusting, and besides, "spiniform corallites" are developed; in *D. petropolitana* there are no "spiniform corallites." I am also unable to say whether this is the *Calamopora incrustans* of Phill. (Geo. of Yorkshire).

4. CERAMOPORA MEGASTOMA, ? M'Coy.

(Pl. 2, fig. 3).

See Notes on Carboniferous Polyzoa, Vine, Jour. Geo. & Polytec. Soc., Yorkshire, 1882, p. 339.

---

* Geological Magazine, April, 1876.

Corallum thin and encrusting, with delicate and apparently structureless walls, but not fused together. *Corallites* large and small, irregularly disposed; but occasionally in transverse rows, large and medium size; the smallest, however, larger than any calicular openings in the previous species. *Monticules* feebly developed, marked by a clustering of a few corallites, rather larger than ordinary.

Localities: Hurst, Richmond. Widely distributed as a Carboniferous species.

In the Geology of Yorkshire, Mr. Phillips describes *Calamopora incrustans*, and I have figured a few cells of a species, and drawn up the above description as if the present form was a coral—of which I have serious doubts—to show the contrast between the present and Scotch specimens of *C. megastoma*, M'Coy. The fig. is drawn by the aid of the Camera lucida, and I cannot, from the closest scrutiny of the surface, find sufficient evidence to associate the Yorkshire with the Scotch form. Yet I believe that the two forms may be united if other material was at hand to help me to do so. In the interspaces of the Scotch form there are peculiar porous interspaces which I pointed out and figured in my paper "Review of the Fam. Diastoporidæ," Quart. Jour. Geo. Soc., 1880, and in one of the figs.* of Mr. Ulrich's there is a section of *Eridopora megastoma* Ulrich, identically the same as my own, but without the least reference to the pages of the Quart. Jour. of the Geo Soc., where *Ceramopora megastoma* was described and figured four years previous to the description of Mr. Ulrich, unless he had described the form in a previous work unknown to me. It is not by way of complaint merely that I make a reference to this peculiar form, but to draw attention to *Ceramopora megastoma* of the Scotch beds, *C. megastoma* of the Yorkshire shales, *Eridopora megastoma*, Ulrich, an American form, and *Fistulopora minor*, M'Coy, as being species closely allied, if not identical. Mr. John Young, however, in the Ann. Mag. Nat. Hist., Dec., 1882, affords ample and interesting particulars in an able paper on the probable identity of *C. megastoma*, M'Coy, with that of *Fistulopora minor*, M'Coy.

---

* Jour. of Cincin. Soc. Nat. Hist., Vol. VII., pl. 3, fig. 8, April, 1884.

In my description of all the above fossils I have preferred to use the terms—Corallum, Corallites, and Calices—used by Prof. Nicholson in his descriptions of the Monticuliporidæ. I have no desire, however, to prejudice any investigator as to whether the Monticuliporidæ belongs to the Polyzoa or to the Cœlenterata. I have asked Prof. Nicholson whether his opinions on this point are changed since the publication of the work on the "Genus Monticulipora," or in any ways affected since the publication of the later researches of Mr. E. O. Ulrich? He assures me in a letter that they have not, that he still adheres to the belief that the Monticuliporidæ are Cœlenterata; and for the present I must be forgiven if I sin on the same side, though I will admit that we sin against very competent authority on the opposite side.

Additional notes on rare species of Carboniferous Polyzoa found in the Yorkshire shales.

See Notes on the Carboniferous Polyzoa of North Yorkshire, 1882; Notes on the Carb. Polyzoa of W. Yorkshire and Derbyshire, 1884; Papers published in the Jour. Yorkshire Geological and Polytechnic Soc., Dates above.

Family RHABDOMESONTIDÆ, Vine.

Fourth report on Fossil Polyzoa (Vine), Brit. Assoc. Reports, 1883. American Palæozoic Bryozoa, Ulrich—Jour. Cincin. Soc. of Natural Hist., April, 1884.

In the American work cited above, Mr. E. O. Ulrich has adopted the family name Rhabdomesontidæ, and he has included with the Genus *Rhabdomeson*, Young, that of *Rhombopora*, Meek, and in all probability he will associate with it the Genus *Anisotrypa*, Ulrich. I am rather glad of this, because the association enables me to place in the family several obscure fossils—not abundant—but present in our North Yorkshire and Scotch shales, which have heretofore been placed in doubtful company.

RHOMBOPORA, Meek, 1871.

"Zoarium ramose, branches slender. Zoæcia tubular, radiating in all directions from an imaginary axis; walls abruptly thickened in the "matured" region, where the diameter of the visceral cavity is also more or less constricted. Zoæcial apertures circular or oval, placed at the bottom of more or less obviously impressed, sloping rhomboidal to hexagonal "vestibules." Ridges separating vestibules spiniferous, spines hollow, often of two kinds, large and small, the latter most numerous, and surrounding the apertures in a single or double series, while the larger spines are usually developed only at the upper extremity of the cell."*

Type of Genus *R. lepidodendroidea*, Meek, Upper Coal Measures, Western States: Nebraska and Wyoming. My type specimens are from the Chester Carb. Series. U.S., America.

1? RHOMBOPORA LEPIDODENDROIDEA, Meek.

Palæontology Eastern Nebraska, Meek, 1871, p. 141, pl. VII, fig. 2.
Ulrich, Jour. Cincin. Soc. Nat. Hist., April, 1884, pl. I., fig. 1, 1*a*, & 1*b*.

In the Yorkshire shales I have two or three specimens that I rather hesitate to place here as identically the same as the American species, but if not the same, the species is a very close ally, but much more slender than the American form.

Locality: Hurst, North Yorkshire.

2. RHOMBOPORA PERSIMILIS, Ulrich.

Jour. Cincin. Soc., Nat. Hist., Ap., 1884, p. 30, pl. I, fig. 7*a*, 7*d*.

The Zoarium of this species is ramose and slender, but far more bulky than the more delicate, or even the robust forms of *Rhabdomeson gracile*, Phill. The mode of branching, however, is the same; thrown off at right angles from the main stem. Zoæcia arranged very regular in vertical series; apertures elliptical and ornamented by larger spines at the bottom of each aperture, and by very delicate spines on the margins of the cells. The vestibules of the Yorkshire specimen are similar to that figured by Mr. Ulrich, and allowing for slight variations, I regard the Yorkshire and the American forms as identical as forms so widely separated could possibly be. Mr. Ulrich, however, says (op. cit., p. 30) "It is almost impossible to separate fragments of *Rhombopora persimilis* from those of *Rhabdomeson gracile*, Phill. by their external character. Sections of the two forms show conclusively that the two are different." This opinion, however, must be somewhat qualified as regards the Yorkshire specimens, for though these now described have lain by me for years, I have refused to lable them *R. gracile*; and when seen side by side with the true *R. gracile*, from the same beds, the differences between them are easily recognisable.

---

* Two sentences left out which have reference to Diaphragms and centrally perforated opercular.

Localities: Brit. forms: Hurst, Yorkshire; American forms: Kaskaskia group of Low. Carb. Rocks., Chester, Ill., and Tateville Ky. (Ulrich).

In justice both to Mr. Meek and also Mr. Ulrich, I desire to make reference to a remark in p. 25 of the Journal of the Cin. Soc., Ap., 1884. Mr. Ulrich says "Mr. F. B. Meek, the author of *Rhombopora*, regarded the Genus as belonging to the Polypi (Cœllenterata ?). Against this view I will simply say, that if *Rhombopora* is a coral, then we have no *Bryozoa* in American Palæozoic Rocks." I would not have cared to state an opinion so dogmatically, but I may be allowed to say that I accepted the Genus *Rhombopora* as described by Mr. Ulrich, for the simple reason that in none of his figures the author has given us veritable "tabulæ" (Diaphragms), except in the doubtful presence in figs. 1*a* and 2*b*. *R. lepidodendroidea* and *R. crassa*, and in his definition of the Genus *Rhombopora* he says "Diaphragms (*tabulæ*, Nicholson) generally absent, always few."

3. STREBLOTRYPA NICKLISI, Ulrich (MS., 1884), pl. XXI., figs. 4-5.

The above is a MS. name, but I have no desire to give another to the present form, for several reasons; but the chief one, however, is this. In 1883 Mr. Nickles sent me some specimens of a peculiar Polyzoon, which he asked me to identify, if possible, with Brit. Carb. forms. I could not at the time, but I wrote him that the nearest ally of the American species was the *Hyphasmopora Buskii*, Eth., jun. I told him also that it was not the same species as ours, but I considered that it may be well to place it in the same Genus. At the same time that he sent mine, he sent Mr. Ulrich some also from the Carb. Strata of Kaskaskia, Ill. Since then Mr. Nickles writes me—Feb. 1884—to say that Mr. Ulrich had named the species as above, in honour of the discoverer, but that as the name was only a MS. one, it had no validity. In re-working the whole of my un-named species for this paper, I am happy to say that I have found a fragment of *Streblotrypa Nicklisi* among my Yorkshire material, and this with the *Rhombopora* species will show that by some means the British and American Carboniferous Polyzoa had a common ancestral origin, but it is difficult to say where species originated.

One of the differences between certain of the American and the Yorkshire forms may be noted. In some specimens of *S. Nicklisi*, Ul., from Kaskaskia, there appears to be delicate ridges developed in parallel or wavy lines, which seems to separate the cells into parallel or waving rows; in other specimens, especially in the younger portions of the branch, that is in the apices, there are no ridges, and in this respect both the American and British forms agree. The possession of other fragments from the British rocks would reveal perhaps the separating ridges also, but my own Yorkshire specimen is the younger or growing part of the branch.

The specimen described is about 1¼ line in length, and about ¼ line in width. In the whole length of the fragment taking a row of cells, I find there are about 7 cells, or being more accurate, 6½ cells. A fragment of the American form of the same dimensions, for some specimens are more bulky than ours, affords the same results.

Localities: Hurst, Yorkshire; Kaskaskia, Ill.; Chester group.

Reference to Pl. XXI.

Fig. 1, Heterotrypa delicatula, Vine, natural size and magnified.
Fig. 2, Diplotrypa sp., var. petropolilanaforma, Vine, ,,
Fig. 3? Ceramopora megastoma. Yorkshire specimen.
Fig. 4, Streblotrypa Nicklisi, Ulrich. Yorkshire form.
Fig. 5, ,, ,, ,, American form.

Only in some cases there are three rows of punctures below the cells mouth.

The present paper completes my record of researches on Yorkshire Monticuliporidæ and Polyzoa, unless other material be forthcoming. It is a great pity that our younger naturalists can find so little to interest them in Yorkshire material. In writing to me in acknowledgement of the receipt of my paper on North Yorkshire *Entomostraca*, Mr. J. W. Kirkby remarked, "You will probably find many more species of *Entomostraca* in the Carb. Rocks of Yorkshire, if you continue your researches, especially in the calcareous shales of the lower members." And in the same letter he directed my attention to the rotten Permian material found in the quarry near Hampole: a locality mentioned in his paper on the South Yorkshire Permians. Will students living near these localities kindly search the shales and Rotten Permian Limestone for me, as mine is largely home, and very little out work?

ON THE COMPOSITION OF THE "COAL BALLS" AND "BAUM POTS" IN THE LOWER COAL MEASURES. BY H. B. STOCKS.

IN the Halifax Hard Bed Coal seam it is well-known that nodules occur in abundance; these nodules are locally known as "coal balls." Just above the coal is a bed of shale in which nodules called "baum pots" are found; the latter is divided from the coal by a thin shale containing *Aviculopectens* in abundance; under the coal is a hard fire-clay called ganister.

"Coal balls" are generally spherical, of a brown or greyish-brown colour internally, they are very hard and contain the remains of plants, in some instances being largely composed of wood fossilized by carbonate of lime; they have generally a coating of iron pyrites, which occasionally replaces the carbonate of lime and becomes the chief constituent of the ball.

"Baum pots" may be divided into two kinds—first, those consisting of successive coatings of mineral matter surrounding a central portion; second, those showing stratification like the shale in which they occur. "Baum pots" are generally oval, of a grey colour, hard and compact and often contain fossil shells. They have frequently an outer coating of iron pyrites.

I am not aware that the composition of these nodules has been examined in detail, it being generally stated that they are composed of limestone coated with iron pyrites. With a view to learn something more as to their composition I have made analyses of two "coal balls" and one "baum pot" from the Halifax district. On examination of the "coal balls" qualitatively I found the following:—Ferrous oxide, manganous oxide, alumina, lime, magnesia, silica, sulphuric acid, carbonic acid, phosphoric acid, iron pyrites, and organic matter; and in the "baum pot," ferrous oxide, alumina, lime, magnesia, silica, sulphuric acid, chlorine, phosphoric acid, and iron pyrites.

The quantitative estimations give the following figures:—

	Coal Balls.		Baum Pot.
	Bradshaw.	Stock's Pit.	Swan Bank.
FERROUS OXIDE	3·210	0·167	3·26
MANGANOUS OXIDE	Trace.	——	——
ALUMINA	0·327	Trace.	1·58
LIME	36·170	46·100	51·79
MAGNESIA	0·879	0·299	Trace.
SILICA	1·159	1·209	2 05
SULPHURIC ACID	0·151	0·010	Trace.
CHLORINE	Trace.	——	Trace.
CARBONIC ACID	29·000	35·280	40·65
PHOSPHORIC ACID	Trace.	Trace	0·42
IRON PYRITES	21·581	12·168	0·16
WATER	0·309	3·006	0·09
ORGANIC MATTER AND LOSS ...	7·214	1·761	——
	100·000	100·000	10·000

On looking at the figures of the analyses we find that the "baum pot" contains 0·42 per cent of phosphoric acid, the "coal balls" only containing a trace of it. If, as Mr. Binney thinks (see quotation in Proceedings for 1878), the coal balls have been formed from the shells in the roof of the coal, the substance that they are composed of would have come from some distance higher, the carbonate of lime being soluble in carbonic acid water, and the phosphate of lime insoluble, the carbonate of lime would be dissolved by such water percolating through the rock, and be carried by it into the coal, where the carbonate of lime would deposit round some stem or other part of a plant, thus forming a coal ball; the phosphate of lime being left with the decomposing shells, which would themselves become gradually covered by carbonate of lime from the surrounding shells, and in time form a "baum pot" which would contain most of the phosphoric acid of the shells, thus accounting for the presence of it in greater quantity in the "baum pots" than in the "coal balls."

The amounts of silica and alumina are also larger in the "baum pot" than in the "coal balls," this would seem to show that the carbonate of lime in forming the "baum pot" had enclosed some of the shale, which did not occur in the formation of the "coal balls."

ON THE FIRE-DAMP DETECTOR, WITH RECENT IMPROVEMENTS IN THE MINERS' SAFETY LAMP; AND SOME REMARKS ON THE DIFFICULTIES CONNECTED WITH DEEP MINING. BY W. E. GARFORTH, C.E.

THE early history of the safety lamp is, that in the year 1815, Sir Humphrey Davy and George Stephenson, the celebrated railway engineer, unknown to each other, invented the lamps known by their respective names.

It is generally admitted that Dr. Reid Clanny, of Sunderland, first conceived the idea in 1813, but as his lamp was dependent upon a supplementary appliance, and not on the surrounding atmosphere, the credit is given to Davy and Stephenson, both of whom received public recognition for the invention.

The safety of the Davy lamp is based on the principle that a flame in passing through a metal gauze of a certain mesh (the standard at present is about 784 apertures to the square inch), loses so much of its heat as to be incapable of igniting the explosive atmosphere surrounding it.

Safety lamps when first introduced were received with some distrust, but after a time the Davy, with apertures of $\frac{1}{40}$ to $\frac{1}{60}$ of an inch in diameter, became to be implicitly relied upon, especially in a current moving at a slow velocity. The Davy lamp now exhibited, is supposed to be a fac-simile of Sir Humphrey Davy's original lamp, the first ever used in a coal mine, and was sent by him, in the early part of 1816, to the Rev. John Hodgson, Vicar of Heworth, Newcastle-on-Tyne, and afterwards presented by his relatives to the School of Mines, in London. This lamp is almost identical with the Davy of to-day, the slight difference being in the strength of some of the parts, an improvement which any ordinary workman could suggest.

About the year 1835 the Davy lamp was proved unsafe in an explosive current of 6ft. per second, and since that time some of our most eminent scientific men have endeavoured to find a safer light. The result has been, that more than 100 different patents have been taken out. For many years past the writer has been endeavouring to discover a Light without a Flame sufficient for practical use in the mine. Experiments have been conducted on Phosphorus, the Electric Light, and different kinds of safety lamps. Without troubling you with the details of such experiments, it may perhaps be well to state the danger of applying the Electric light in mines. There is an impression that the incandescent lamps (now in general use on the surface) might be used with advantage, if sufficient electricity could be stored in a portable form, but the objection is that if electric wires are allowed to cross each other and then separate, an action similar to the effect produced by a fall of the roof, electric sparks are emitted by which the gas has been ignited. What is required in a mine is not only a light, but an indication to the miner that the atmosphere surrounding him is sufficiently pure to breathe.

The principal requirements of a safety lamp are:—to be so sensitive as to indicate at once the presence of gas, by allowing the atmosphere to reach the flame without obstruction, and yet so shielded as to resist an explosive current moving at a high velocity; that an ample supply of air may be obtained to support combustion, and yet have some internal arrangement by which the products of an explosion inside the lamp will cause it to be self extinguishing;

to be so small as not to be an encumbrance in getting through the small roadways or places to be examined, (also to prevent the force of an explosion inside the lamp bursting the gauze,) and yet so arranged that it will burn for 8 or 10 hours without getting too hot; to be so light that it may be carried for hours without difficulty, and yet so strong as to resist a certain amount of rough usage; to give a good light, not only to enable the miner to get the coal, but to enable him to see the breaks in the roof (it has been stated there are more accidents from falls of roof, on account of the poor light given off by the Davy or Stephenson, than with the candle.)

The comparative lighting power of some of the principal lamps now in use is as follows:—

English Standard sperm candle burning 120 grains per hour	100
Improved Mueseler	70
Davy	37
Stephenson	20

The writer succeeded about three years ago in constructing a lamp unlike any existing one, which fulfilled many of the before mentioned requirements, but as it was dependant on the movement of a small fan to obtain and regulate the supply of air, it could not be recommended for daily use, as some of the parts were liable to derangement owing to the dust in the mine. As an instance of the difficulty of obtaining a perfectly safe light, it may be stated that recently a prize of £500 was offered by Mr. Ellis Lever, and 108 different lamps competed, but no lamp fulfilled the conditions ordinarily required in a mine, and the prize was not awarded.

During the last few years, and based on a great number of experiments and trials, several improvements have been made in the lamp, the most important being the Mueseler Chimney and the Tin Shield. The object of the chimney is to throw back the carbonic acid gas (the result of the explosion inside the lamp) on to the flame and so extinguish the light. With a properly constructed chimney where all the space can be filled with carbonic acid gas, the flame of the lamp, in an explosive current of 19 feet per second, is extinguished before firing the gas outside. Above that velocity, and with the current directed to the upper part of the internal chimney, the flame can be drawn (somewhat on the principal of the Injector) to the top of the chimney, when it simply acts like the Davy, as there is then only the gauze between the flame and external atmosphere. If, however, the lamp is fitted with a tin shield securely fastened to the middle flange of the lamp, the chimney and gauze are so protected that lamps of this description have been made to resist a velocity of 51 feet per second. This velocity is more than is required under ordinary circumstances, but it is difficult to say what is required to resist the extraordinary conditions met with in mining, such as the concussion of air produced by a blown out shot, or after a heavy fall of the superincumbent strata, either of which might force a large volume of explosive mixture at a high velocity on to the lamp. Considering the cubical capacity of a large goaf as compared with the narrow roadways leading thereto, it may be imagined that a velocity of more than 50 feet per second results when a heavy fall takes place. Judging from the latest trials, it is thought that at 60 feet per second no existing lamp is safe. The advantages of resisting a high velocity are undoubtedly very great, and will become of still greater value year by year in those deep and extensive mines where large volumes of air are required for ventilation and for reducing the temperature of the strata at great depths. In my opinion, however, the advantages of the tin shield and double or trible gauze have been gained by shielding or placing a species of obstruction between the flame and external atmosphere. Such being the case, the old argument that the mine can be kept safer by using the Davy, which detects small quantities of gas, still holds good in a sluggish ventilation. The Davy is known to be most unsafe, for the reasons mentioned of not being able to resist velocity, and was some years condemned in Belgium; and in many English mines. The last serious explosion in this country, happened at Altham, in Lancashire, by which 39 lives were lost, and a great number injured; the accident was traced beyond doubt to the use of the Davy, and since the explosion the Tin shield lamp has been substituted.

From the foregoing remarks it would seem that in any existing safety lamp where one qualification is increased, another is proportionatelp reduced; so it is doubtful whether all the necessary qualifications can ever be combined in one lamp. The writer believes they cannot, and with a view of making the Tin shield or any other description of protected lamp as equally sensitive as the Davy, he has invented the Detector as the most suitable adjunct or second vessel to the lamp.

The Detector, as will be noticed from the one exhibited, simply consists of an India rubber ball, so small that all the air within it is expelled by the compression of one hand, and a pure sample of the suspected atmosphere obtained. If the ball were larger, and a portion of the air remained, the sample would then be diluted. It has been found by a great number of trials that it obtains quite sufficient gas for testing purposes. That only one hand should be engaged in testing is an indispensible condition, on account of holding the lamp, &c. It will be apparent that by the ordinary action of compressing the ball and then allowing it to expand, a vacuum is formed within it, and a sample of the suspected atmosphere drawn from the breaks and cavities of the roof or any part of the mine.

When the sample is forced through the tube near the flame, gas, if present, at once reveals itself by the elongation of the flame in the ordinary way; at the same time burning with a blue flame at the top of the test tube. If gas is not present, the distinction is easily seen by the flame keeping the same size, but burning with greater brightness owing to the increased quantity of oxygen forced upon it.

The advantages claimed for this method of detecting fire-damp are:—

1.—The Detector, on account of its size, can be placed in a break in the roof, where an ordinary lamp—even a small Davy—could not be put; and a purer sample of the suspected atmosphere is obtained than would be the case even a few inches below the level of the roof.

2.—The method of obtaining and testing a sample as above described, takes away the possibility of an explosion, which might be the result if a lamp with a defective gauze were placed in an explosive atmosphere.

(Although lamps fitted with a tin shield will be subjected to the same strict examination as hitherto, still they do not admit of the same frequent inspection as those without shields, for in the latter case each workman can examine his own lamp as an extra precaution, whereas the examination of the Tin shield lamps will rest entirely with the lampman).

3.—The lamp can be kept in a pure atmosphere, whilst the sample is obtained by the Detector, and at a greater height than the flame in a safety lamp could be properly distinguished. The test can afterwards be made in a safe place at some distance from the explosive atmosphere; and owing to the vacuum formed, the ball (without closing the mouthpiece) has been carried a mile or more without the gas escaping.

4.—The Detector supplies a better knowledge of the condition of the working places, especially in breaks and cavities in the roof, which latter, with the help of a nozzle and staff may be reached to a height of ten feet or more, by the Detector being pressed against the roof or sides, or by the use of a special form of Detector.

5.—Being able at will to force the contents of the Detector on to the flame, the effects of an explosion inside the lamp need not be feared.

6.—The use of the Detector will permit the further protection of the present Tin shield lamp, by an extra thickness of gauze, if such addition is found advantageous in resisting an increased velocity.

7.—In testing for gas with a safety lamp, there is a fear of the light being extinguished, when the lamp is suddenly placed in a quantity of gas, or in endeavouring to get a very small light; this is especially the case with some kinds of lamps. With the Detector this is avoided, as a large flame can be used, which is considered by some a preferable means of testing for small quantities, and the test can be made without risk. Where gas is present in large quantities, the blue flame at the end of the test tube will be found a further proof. This latter result is produced by the slightest compression of the ball.

(I need not point out the inconvenience and loss of time in having to travel a mile or more to re-light.

Although the question of safe lighting is one of the most important connected with coal mining (for without a light no work could be done), still there are other serious difficulties to contend with, in consequence of the increased depth at which coal will in the future have to be won. Fortunately, large quantities of water (which in some shallow pits has been the chief drawback to the mine being worked profitably) are seldom met with at great depths; and fire-damp, which might naturally be expected to be given off in greater proportions, owing to the increased weight of the the superincumbent strata, is found to be little, if any more, than in mines lying nearer the surface. The cost of actually raising the coal is not seriously felt, on account of the various improvements which have been made in ropes, compensating winding drums, regulating valves, and the more economical use of fuel in both engines and boilers. The improved manufacture and reduced price of steel has contributed very materially to these and other advantageous results.

The principal difficulties of deep mining are, increase of temperature, and the effects of the weight of the superincumbent strata. With reference to the former, it was thought, about the time the Royal Commission was appointed to enquire into the probable duration of the English coal-fields, that the temperature of the strata increased about one degree for every fifty feet, (after sixty feet from the surface); but recent sinkings have proved the increase is not so great, being only one degree for every seventy-six to seventy-nine feet. At Ashton Moss Colliery, near Manchester, the deepest shaft in England, and at Dukinfield Collieries, Cheshire (with both of which the writer is well acquainted), the temperature at 2,880ft. deep is eighty-four to eighty-five degrees.

The natural temperature of the strata has been much reduced in some mines, by passing large volumes of air at a low temperature along the roadways; but as deep mines will have to work extensive areas to save the cost of sinking additional pits, it follows that in an increased length of air-way, the air will become warmer, and less able to absorb the heat given off by the surrounding strata. To obtain sufficient air for cooling purposes, in addition to the ordinary requirements connected with the men, horses, lights, and diluting the noxious gases, a great increase of motive power will be required.

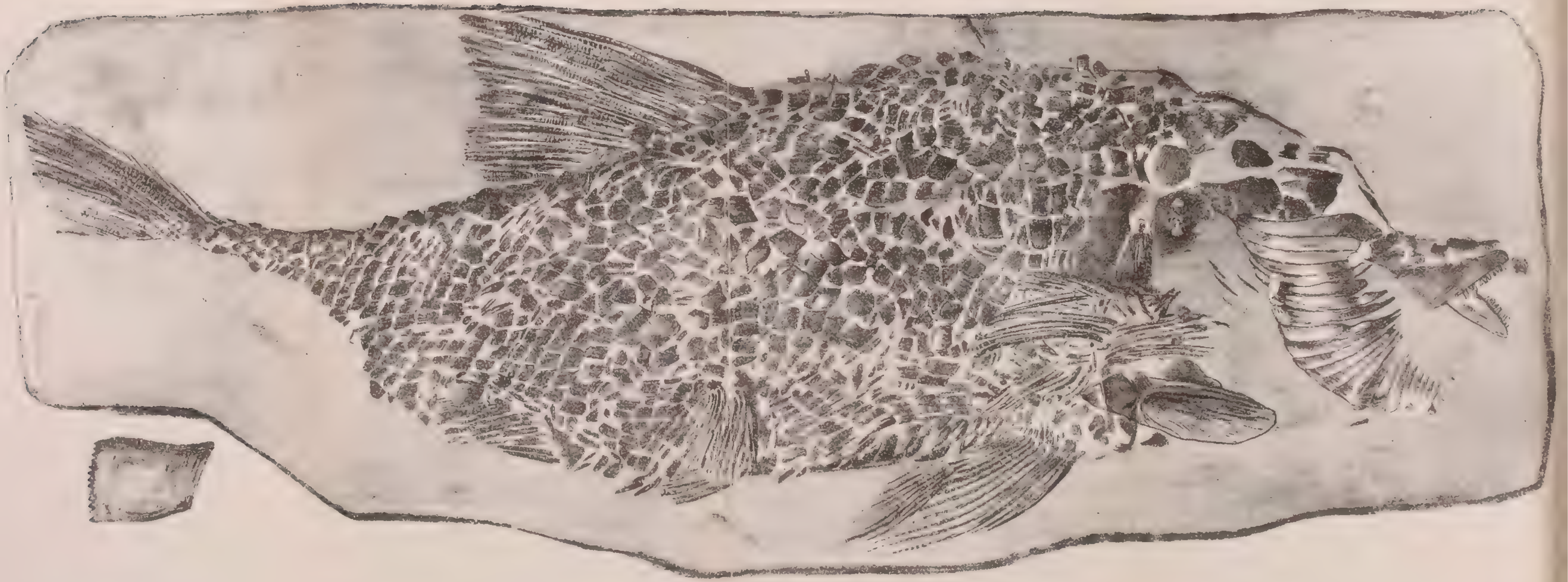
The greatest help to obtain this increased quantity is by a larger sectional area. This raises the second difficulty of dealing with the effects of the superincumbent weight.

Considering the difficulty and heavy cost of increasing the velocity, it becomes a question whether it will not in the future be more advantageous to reduce the temperature by artificial means.

As regards the effects of the superincumbent strata at great depths, it seems to be a difficulty quite as serious as increase of temperature. Pillars of coal, which formerly resisted the effects of the overlying strata, are now much crushed even if a larger proportion of pillar be left. Of course no system of working can diminish the pressure, but on the contrary, must increase it. The faults of a wrong system of working, which were not apparent at shallow depths, are now seen by an increased proportion of small coal, which in most instances makes the difference between profit and loss. There is also the difficulty (a most serious one) of the liability of sudden outbursts, which has been the cause of several dreadful colliery explosions.

From the foregoing it would seem that coal has been placed within our reach, but apparently too deep for work; and when the hands are stretched forth to obtain it, a sacrifice of life takes place. But when we remember, and from statistics published by the Royal Commission, that only 60 per cent. of the produce of the seam was formerly obtained in some districts, it would appear as if coal had been Divinely stored at a great depth to prevent it being wasted, both in the method of getting and in the consumption. At the present time, as much as 95 per cent. (in some cases more) of the seam is obtained, and 2½lbs. of coal per hour per horse power, is now doing the same amount of work that some years ago required 4 to 5lbs.

The writer believes it is possible to overcome many of the difficulties that have been referred to, by a better and more systematic method of working. When we take into account that most mines rest upon an under clay, it will be understood that the same pressure which is crushing the coal is also affecting the dirt. If that effect is only properly studied, it is possible it may not only be the means of saving the coal, but by being crushed into suitable pieces for packing, it will enable the goaf to be filled, and thus



[illegible] [illegible]

HETEROLEPIDOTUS MINOR, *Davis*

reduce the cause of sudden outbursts to a minimum; at the same time prevent accumulations of gas, and form good roadways without leakage for the ventilation.

An eminent writer asks, "May it not be said that the experiments of science are the answers made by nature, to the questions put to her by man." This remark may for many reasons be considered specially applicable to mining. If the laws of nature are scientifically and properly studied, it will be found that the difficulties of deep mining are far less than at present apprehended; and though we may for a time be perplexed, yet in the long run it will be proved in mining, as in other things, that the fault does not rest with nature, whose wonderful laws appear grander and more marvellous the better they are understood.

ON A NEW SPECIES OF HETEROLEPIDOTUS FROM THE LIAS.

BY JAMES W. DAVIS, F.G.S., &c. (PLATE XXII).

Genus HETEROLEPIDOTUS, Egerton.

HEAD large; snout obstusely conical; maxillary and mandibular bones straight; teeth of various sizes, the larger ones strong and bluntly pointed; the smaller ones sharp and numerous; gape wide; pectoral and ventral fins large; dorsal fin remote; scales large, thick, and lustrous, more or less serrated on the posterior margins; abdominal scales small and elongated; tail broad, the upper lobe ridged with strong fulcral scales. (*Egerton.*)

HETEROLEPIDOTUS MINOR, Davis.

The specimen which forms the subject of the following description has been in my cabinet for some years awaiting the discovery of others which would exhibit more perfectly the characters lacking in this one. The body of the fish represented by the accompanying plate is slightly distorted so that the abdominal region is brought prominently forward, and both the right and left pectoral and ventral fins are exhibited in a more or less perfect condition. The scales are displaced; the head is imperfect; the whole of the cranial bones have disappeared; the lower portion of the head is however preserved. The larger part of the tail is also wanting; the dorsal fin is well preserved; and the outline of the body clearly indicated, the latter gracefully fusiform. The length from the tip of the snout to the base of the tail is about 13 inches, to which must be added 3 inches for the tail; the imperfect state of the head renders its exact length slightly uncertain, but of the length named, the head probably occupied 4 inches. The greatest depth of the body is between the dorsal and ventral surfaces, immediately behind the pectoral fin where it is 4 inches; from this diameter the body tapers gradually backwards to about 1·5 inch at the base of the tail.

The *head* was probably large; the parts preserved comprise the upper and lower jaws, a number of branchiostegal plates, and some bones of the cranium. The part of the upper jaw preserved is an inch in length; broad posteriorly, but rapidly tapering to a more or less acuminate termination anteriorly; it contains 16 or 18 teeth uniform in size, 0·6 of an inch in length, conical in form, pointed, and slightly curved inwards. The lower jaw is similarly armed to the upper one. The exposed branchiostegal plates or rays are 18 in number; the largest is 1·5 inches in length, and ·15 in breadth, they diminish in size towards the median line, the shortest being ·85 of an inch in length. There were probably 12 or 14 rays on each side, in this specimen it is difficult to determine where the median line was, the rays from the opposite side being exhibited in close contact with those on the more exposed one. The plates are flat, imbricating, smooth, and covered with glistening enamel. Parts of other bones, enamelled and more or less pustulate are also preserved, but not so well as to be easily identified.

The *scales* are large, thick, more or less rhomboidal in outline, covered with ganoine and frequently shewing concentric lines of growth; those on the anterior median portion of the body are serrated along the posterior margin as shown in the enlarged drawing of a scale taken from the laternal line about 2 inches behind the head (pl. XXII., fig. 1a.) The scales midway between the dorsal and ventral surfaces of the body are largest, the exposed part of the scale being equal in height to the length, an additional portion, equal to one-fourth of the part exposed, is overlapped by the succeeding scale. The scales enveloping the dorsal region are smaller but of similar form to the median ones. except at the base of the dorsal fin where they are somewhat elongated. Those on the ventral surface are as long as those on the lateral line but they are not more than half the breadth, and in a few instances they assume the form of an elongated triangle. The scales on the posterior surface of the body are smooth and the overlapping edge of the scale is not serrated.

The *dorsal fin* is large, extending nearly 3 inches from the body. It occupies a position opposite to the interval between the ventral and dorsal fins; the insertion of its anterior rays being 8 inches from the snout. Twenty-four rays are preserved. The anterior one is longest, and is divided by numerous transverse joints, about an inch from the base, the rays thicken and then divide into two branches, these again dichotomize, so that the distal ends of the fin-rays are divided into four and sometimes eight filamentous branches each of which is composed of numerous ossicles with transverse articulations. Fulcral scales do not appear to have been present.

The *pectoral fins* are large and powerful: 2·5 to 3·0 inches in length. In the specimen represented on pl. XXII the posterior portion is folded over so that the full size of the fin is not seen. It is composed of 18 to 20 rays, the base of these is expanded with a joint-like surface for articulation to the pectoral arch, some of the bones of which are preserved and shewn on the figure between the pectoral fin and the branchiostegous plates. A number of small scales occupying the surface of the body at the base of the fin, similar, but more elongated than those of *H. latus* described by Sir. P. Egerton. The basal portion of each fin-ray is smooth and fluted to the extent of about 1 inch; beyond that distance they become numerously jointed and repeatedly dichotomize as in the dorsal fin. There is no appearance of fulcral rays. The opposite pectoral fin is exposed, much disturbed and broken, a portion of the rays are bent over towards the head.

A portion of each *ventral fin* is preserved, but neither perfectly they are situated opposite to the anterior insertion of the dorsal fin; the rays are strong and were powerfully attached, and by inference should have strong internal support. The number of rays cannot be determined.

The *anal fin* was large and powerful. It is imperfect, but sufficient is preserved to shew that the rays were thicker though shorter than those of the pectoral or ventral fins; the longest ray is only preserved to the extent of ·75 of an inch, of this ·5 of an inch at the base is smooth with a single longitudinal groove, the remaining portion being composed of closely jointed ossicles.

The *candal fin* is partially preserved, the whole of the lower lobe of the fin has been broken off and lost during the extraction of the specimen from the matrix. From the portion preserved, it appears that there was a prolongation of the vertebræ to the upper lobe but to what extent is not exactly defined. A number of strong, pointed, imbricating scales, envelope the base of the tail on the dorsal surface, and were continued some distance along the margin of the fin. The rays forming the upper lobe of the tail are strong at the base, consisting of ossicles equal in length to their breadth, attached by transverse articulations; at about ·8 of an inch from the base they dichtomize, each branch being again divided.

Sir Philip de Malpas Grey Egerton in the XIII Decade of the Geological Survey, separated two species described by Prof. Agassiz as *Lepidotus fimbriatus* and *L. serrulatus*, and constituted for them a new genus which he named Heterolepidotus. They differ essentially in two particulars from the typical Lepidoti and approach the Sauroid family Eugnathus. The differences are in the characters of the teeth, and the scales of the ventral surface of the body. The teeth in the true Lepidoti are either large and round like the tritorial teeth of the Pycnodonti, or obtusely conical and uniform in size; in Heterolepidotus they are sharp and elongated, of various sizes and very numerous. The scales of Lepidotus are uniform, or nearly so in size, over the whole surface of the body, whilst in Heterolepidotus they are considerably elongated and narrow on the under side of the body, resembling those of Eugnathus. The species now described appears to have a somewhat contracted gape, and the teeth are short, conical and uniform, and in these respects it approaches the characters of the true Lepidoti. The scales on the other hand resemble those of the examples constituting Egerton's genus Heterolepidotus, they are larger along the median line in proportion to the fish, than in either of the species from the lias described by Sir P. Egerton (Memoirs of the Geological Survey Decade XIII., pl. 2 and 3,) and the scales of the ventral and abdominal regions, whilst they have the elongated form, do not appear to have been nearly so numerous or occupied so large an area as those of *Heterolepidotus latus*, Eg. The dorsal fin is further removed from the head than in the case of the species hitherto described, and its rays are longer and capable of wider expansion. The form of the fish occupies a position intermediate between the deep-bodied *H. latus*, and the elongated and graceful outline of *H. sauroides* Though considerably smaller than those species it has the characteristics of being mature.

The specimen now described, constitutes the third species of this genus, all from the lias of Lyme Regis. Hitherto no example of the genus Lepidotus has been described from the Lyme Regis locality, whilst in the Yorkshire Lias it is more commonly met with than any other form and Heterolepidotus is unknown. I suggest the name *H. minor*, on account of its comparatively small size, be applied to this species.

Formation and Locality: Lias, Lyme Regis.

SECRETARY'S REPORT.

During the past year two meetings have been held. The members met at Harrogate, in the Conservatory of the Prospect Hotel, on April 23rd. The papers read at the meeting formed a peculiarly interesting series, treating, with one exception, some subjects connected with the Geological or Chemical constitution of the mineral waters of Harrogate. Mr. Richard Carter occupied the Chair, and gave an address; and papers were read by Messrs. C. Fox Strangways, of H.M. Geological Survey, Geo. Oliver, M.D., R. Hayton Davis, F.C.S., R. Lloyd Whiteley, a student at the Yorkshire College, and Thos. Hick, B.A., B.Sc. and Wm. Cash, F.G.S. At the conclusion of the meeting, Mr. Carter entertained the members present, nearly 50 in number, at dinner, and a discussion on the objects and work of the Society terminated an extremely interesting and agreeable meeting.

The second meeting was held at Leeds, in the rooms of the Philosophical and Literary Society, on Wednesday, Oct. 22nd, 1884. The Chair was occupied by Professor Bodington, Principal of the Yorkshire College; and papers were read by Messrs. Geo. R. Vine, H. B. Stocks, W. E. Garforth, C.E., and James W. Davis, F.G.S.

The number of members is now 220; of this number 26 have compounded for the annual subscription, and become life members; the remaining 194 are ordinary members. During the past year 3 members have withdrawn from the Society, whilst 12 have been added; leaving a net gain of nine members.

The Societies whose names are appended below, receive copies of our proceedings, and in exchange we are indebted to them for copies of their respective publications.

Essex Naturalists' Field Club.
Norwich Geological Society.
Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.

Royal Historical and Archæological Association of Ireland.
Geologists' Association, London.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociètè-Geologique du Nord.
Royal Society of Edinburgh.
Royal Geological Society of Cornwall.
Royal Physical Society of Edinburgh.
Oversigt over det Konigelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Herefordshire Field Club.

The Committee appointed for the exploration of the Raygill fissure have to report that during the past year operations have been entirely suspended, to enable the proprietors of the quarry in which the fissure is situated, to remove by quarrying a large mass of limestone, which greatly interfered with the work of excavation. The removal of this limestone is now becoming rapidly completed, and it is hoped that at an early period during the spring of next year, the examination of the fissure may be resumed. The exploration Committee have pleasure in stating that the British Association at its Montreal meeting renewed the grant of £15 towards the expenses of the work; and they wish to express their sense of the kindness of the proprietors, Messrs. Spencer, who have, at no small inconvenience and considerable cost, greatly facilitated the work of the Committee, besides reducing the cost of its future operations.

The Society is indebted to the following gentlemen who have acted during the past year in the capacity of Local Secretaries; they have, in all cases, exercised painstaking care in the discharge of their duties, and the continued prosperity of the Society no doubt depends in a large degree on their efforts. The following is a list of the Local Secretaries, and the towns or districts under their supervision :—

Barnsley	Thomas Lister
Bradford	Thos. Tate
Bridlington	G. W. Lamplugh
Driffield and District	Rev. E. Maule Cole, M.A., &c.
Halifax	Geo. Patchett, Junr.
Huddersfield	Peace Sykes
Leyburn and Wensleydale	William Horne
Selby	J. T. Atkinson
Thirsk	W. Gregson

As on so many previous occasions, it is with pleasure that the Society has to acknowledge its indebtedness to Mr. W. H. Dalton, of H.M. Geological Survey, for the assistance he has been able to afford in the compilation of the Bibliographical list of works and papers relating to the geology and cognate sciences of Yorkshire published during the past year.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, 1883-4.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	10	0	0	By Cash paid to Bank	119	19	11
" Subscriptions	119	19	11	" Cost of Printing, Photographs, &c.	97	17	9
" Bank	87	17	9				
	£217	17	8		£217	17	8

THE TREASURER IN ACCOUNT WITH THE BANK.

	£	s.	d.		£	s.	d.
To Balance from last Account	33	15	9	By Cash from Bank	87	17	9
" Cash paid to Bank	119	19	11	" Balance	67	1	9
" Interest	1	3	10				
	£154	19	6		£154	19	6

CAPITAL ACCOUNT.

	£	s.	d.		£	s.	d.
To Balance last Account	165	2	8				
" Subscription	6	6	0				
" Interest	5	15	11				
	£177	4	7	By Balance at Bank	£177	4	7

RAY-GILL QUARRY FUND.

	£	s.	d.		£	s.	d.
To Balance	29	16	1				
" Interest...	1	0	9				
	£30	16	10	By Balance at Bank	£30	16	10

Examined and found correct, GEO. PATCHETT, Junr.

MINUTES.

A Meeting of the Council was held on April 23rd, 1884, at the Conservatory, Prospect Hotel, Harrogate.

The Chair was occupied by Richard Carter, Esq., C.E., &c. Present, Messrs. Embleton, Rowley, Cheetham, Parke, Reynolds, Prof. Green, and Mr. Davis.

The Minutes of the last meeting of the council were read and confirmed.

The following accounts were ordered to be paid; on the motion of Mr. Parke, and seconded by Mr. Rowley:—

	£	*s.*	*d.*
A. Megson & Sons - - - -	56	8	3
Autotype Co. - - - -	7	8	1
"Halifax Courier," (advt.) -	0	10	0
,, "Guardian" - - -	0	10	0
Mr. Harrison, "Ripon Chronicle"	0	5	6
Whitley & Booth - - -	2	12	0

Mr. Embleton proposed and Prof. Green seconded "That an excursion be held in Wensleydale, between Leyburn and Hawes."

Proposed by the Hon. Secretary, seconded by Mr. Cheetham, "That the fault at the waterfall at Keld-head be photographed, for distribution to members."

General Meeting held in the Conservatory, at the Prospect Hotel, Harrogate, on April 23rd, 1884.

Richard Carter, Esq., C.E., F.G.S., occupied the chair.

The Minutes of the last annual meeting were taken as read and confirmed.

The Chairman gave an address.

The following papers were read:—

1. "The Harrogate Wells; or the mineral waters of Harrogate geologically considered." By C. Fox-Strangways, Esq., F.G.S., of H.M. Geological Survey.

2 "The mineral springs of the grand anticinal of the West Riding; a few chemico-geological notes." By Geo. Oliver, Esq. M.D.

3. "The mineral wealt hof Harrogate." By R. Hayton Davis, F.C.S.

4. "Analysis of the Kissengen saline chalybeate springs, 1883, as compared with analysis in 1845, 1854, 1867, and 1879." By R. Lloyd Whiteley, Esq., student in the Yorkshire College.

5. "Contributions to the fossil flora of Halifax." Pt. III. By Thos. Hick, Esq., B.A., B.Sc., and Wm. Cash, Esq., F.G.S.

The Hon. Secretary proposed and Mr. Parke seconded. that the following gentlemen be members of the Society:—

Alfred Holroyd,	Halifax.
M. G. Dobson	"
C. Middleton	"

The meeting adjourned at the invitation of the Chairman to an adjoining apartment where dinner was served. After the usual toasts, Mr. Cash proposed the health of Mr. Carter, and expressed the thanks of the Society to him for presiding at the meeting, and his subsequent entertainment of the members.

Meeting of the Council in the Library of the Philosophical and Literary Society, Leeds, on October 22nd, 1884.

The Chair was occupied by J. Ray Eddy, Esq. Present, Messrs. Atkinson, Cheetham, Reynolds, Rowley, and Davis.

The Minutes of last council meeting were read and confirmed.

The following accounts were ordered to be paid:—

	£	*s.*	*d.*
Whitley & Booth - -	2	5	6
J. W. Ackrill - - -	0	9	8

The Honorary Secretary's report and the Treasurer's balance sheet, were read and approved, and ordered to be presented at the annual meeting of the members.

The *Annual Meeting* was held in the Library of the Philosophical and Literary Society, at Leeds, on October 22nd, 1884.

Professor Bodington, Principal of the Yorkshire College, occupied the chair.

The Minutes of last general meeting were read and confirmed.

The annual report was read and adopted.

The Balance sheet was presented by the Treasurer and accepted.

It was proposed by Prof. A. H. Green, and seconded by Mr. J. T. Atkinson, "That the thanks of the Society be given to the several officers for their services during the past year; and that the president (the Marquis of Ripon) and the vice-presidents be re-elected." Carried unanimously.

Mr. Eddy proposed, and Mr. Rowley seconded, "That Mr. Wm. Cash be re-elected Treasurer, and that Mr. James W. Davis be re-elected Honorary Secretary." Carried unanimously.

It was proposed by Mr. Carter, seconded by Mr. Cheetham, and carried, "That the following gentlemen constitute the Council of the Society during the ensuing year:—

Wm. Alexander, M D., J.P.
J. E. Bedford.
W. Cheetham.
T. W. Embleton, C.E.
Prof. A. H. Green, M.A., &c.
R. Reynolds, F.C.S.
R. Carter, C.E.
J. Ray Eddy, F.G.S.
E. Filliter, C.E.
G. H. Parke, F.G.S., &c.
W. Rowley, F.G.S.
W. Sykes Ward, F.C.S.

The Chairman gave an address.

The following papers were read.

1. W. E. Garforth, Esq., C.E., "On the fire damp detector, with recent improvements in the miners' safety lamp, and some remarks on the difficulties connected with deep mining."
2. H. B. Stocks, Esq., "On the composition of Coal Balls and Baum Pots."
3. Geo. R. Vine, Esq., "Further notes on new and other Yorkshire fossils, described by the late Prof. Phillips in his Geology of Yorkshire."
4. James W. Davis, F.G.S., "On a new species of Heterolepidotus.
5. James W. Davis, F.G.S., "On the anatomical structure of the genus Heterolepidotus."

On the motion of Mr. Davis, seconded by Mr. Reynolds, the following gentlemen were elected members of the Society:—

H. J. Hunt, Harrogate.
R. H. Davis ,,
Jno. Leach, Halifax.
A. T. Walmisley, London.
Geo. Paul, Leeds.

Mr. Carter proposed; Mr. A. Lupton seconded, "That a vote of thanks be given to the authors of papers." Carried.

On the motion of Mr. Davis, seconded by Mr. Rowley, the thanks of the meeting were given to Prof. Bodington for presiding.

After the conclusion of the business, the members adjourned to the Queen Hotel, where the Leeds members entertained those from other places at dinner.

SUMMARY OF GEOLOGICAL LITERATURE RELATING TO YORKSHIRE, PUBLISHED DURING 1884, WITH ADDENDA FOR 1880-1883.

Compiled by **JAMES W. DAVIS.**

1880.—ADDENDA.

NATHORST, A. G. Om en med understöd af allmänna medel utförd vetenskaplig resa till England. *Ofv. k. Vet-Akad. Forhändl.*

1883.

CASH, W. Preliminary Report of the Committee .... on the Flora of the "Halifax Hard Bed," Lower Coal Measures. *Rep. Brit. Assoc.* for 1882, pp. 267-268.

CROSSKEY, Dr. H. W. Tenth Report of the Committee for .... recording Erratic Blocks. *Rep. Brit. Assoc.* for 1882, pp. 243-248.

DE RANCE, C.E. Eighth Report of the Committee .... for .... Underground Waters .... *Rep. Brit. Assoc.* for 1882, pp. 213-238.

MORRIS, **JOHN**. The Chalk, its distribution and sub-divisions, *Proc. Geol. Assoc.* vol. viii., pp. 208-226. (Ref. to Yorks. Chalk).

READE, T. M. A Traverse of the Yorkshire Drift. *Proc. Liverpool Geol Soc.*, vol. iv., p. 364.

WOODWARD, Dr. H. Monograph of Carboniferous Trilobites. *Pal. Soc.*

1884.

CASH, W. Report of the Committee ... for investigating the Fossil Plants of Halifax. *Rep. Brit. Assoc.* for 1883, p. 160.

CROSSKEY, Dr. H. W. Eleventh Report of the Committee .... for recording .... Erratic Blocks .... *Rep. Brit. Assoc.* for 1883, pp. 136-146.

DAVIS, **JAMES** W. On a new species of Cœlacanthus *(C. tingleyensis)* from the Yorkshire Cannel Coal. *Trans. Linnean Soc.*, 2nd Ser. Zoology, vol. ii., part 13, pp. 427-433, pl. xlvi.-xlix.

————On the Occurence of the Remains of Labyrinthodonts in the Yoredale Rocks of Wensleydale. *Rep. Brit. Assoc.* for 1883., p. 492.

————On some Fossil Fish Remains, found in the Upper Beds of the Yoredale Series at Leyburn, in Yorkshire. *Ibid*, pp. 492-493.

————Report of the Committee ... appointed to assist in the exploration of Raygill Fissure, Yorkshire. *Ibid* 1883, pp. 133-135.

————On a Pile Dwelling recently discovered at Ulrome, in Holderness, Yorkshire. *Ibid*, pp. 567-568.

————Geological Excursion to Holderness, the Kilnsea Shell Mounds, Spurn Point, and the Pile Dwellings at Ulrome. *Proc. of the Yorksh. Geol. Soc., n.s.*, vol. viii., pp. 269-275.

————Summary of Geological Literature relating to Yorksbire. Published during 1883, with Addenda for 1879-1882. *Ibid*, pp. 285-286.

————On some remains of Fossil Fishes from the Yoredale Series at Leyburn, in Wensleydale. *Quart. Journal Geol. Soc.*, vol. xl., pp. 614-635, pls. xxvi., xxvii.

De Rance, C.E. Ninth Report of the Committee .... for .... Underground Waters .... *Rep. Brit. Assoc.* for 1883, pp. 147-159.

Easterfield, T. H. A Glacial Deposit near Doncaster. *Proc. of Yorksh. Geol. Soc. n.s.*, vol. viii., p. 212, pl. vii*a*.

Fordham, H. G. Report of the "Local Scientific Societies" Committee .... appointed to draw up suggestions upon methods of more systematic observation and plans of operation for Local Societies, together with a more uniform mode of publication of the results of their work. *Rep. Brit. Assoc.* for 1883, pp. 318-345.

Hudleston, W. H. Contributions to the Palæontology of the Yorkshire Oolites. *Geol. Mag.*, dec. iii., vol. i., pp. 107-115, 145-154, 241-252, 293-303. pls. iv., vi., viii., ix.

Lamplugh, G. W. Glacial Sections near Bridlington. Part iii., The Drainage Sections. *Proc. Yorksh. Geol. Soc.*, *n.s.*, vol. viii., pp. 240-254. 2 pls. (map and sections).

————On a recent exposure of the Shelly Patches in the Boulder-clay at Bridlington Quay; with Notes on the Fossils by Dr. J. G. Jeffreys, Mr.E. T. Newton, and Dr. H. W. Crosskey. *Quart. Jour. Geol. Soc.*, vol. xl., pp. 312-328.. pl. xv.

Miall, Prof. L. C. On a new Specimen of Megalichthys from the Yorkshire Coalfield. *Quart. Jour. Geol. Soc.*, vol. xl., pp. 347-352.

Mortimer, J. R. Description of the Origin and Distribution of the Unwaterworn Chalk-gravel on the Yorkshire Chalk Hills, supplemented by an account of neighbouring and somewhat contemporaneous Deposits. *Proc. Geol. Assoc.*, vol. viii., pp. 287-298.

Parkin, C. On the Mineral Resources of the Rosedale Abbey District. *Trans. N. Engl. Inst. Eng.*, vol. xxxii., p. 43.

Tute, Rev. J. S. On the Sequence of the Permian Rocks near Ripon. *Proc. Yorksh. Geol. Soc. n.s.*, vol. viii., pp. 218-220, pl. x.

————Some Indications of a Raised Beach at Redcar. *Ibid*, p. 220.

Veitch, Dr. W. Y. On the Raised Beaches on the North East Coast of Yorkshire. *Proc. Yorksh. Geol. Soc. n.s.*, vol. viii., pp. 221-226.

Vine, G. R. Notes on the Carboniferous Polyzoa of West Yorkshire and Derbyshire. *(An Attempt to Identify Phillips' Species). Proc. Yorksh. Geol. Soc. n.s.*, vol. viii., pp. 161-174.

————Notes on the Carboniferouos Entomostraca and Foraminifera of the North Yorkshire Shales. *Ibid*, pp. 226-239, pl. xii.

⁂ The Society is much indebted to the kindness of Mr. W. H. Dalton, late of H.M. Geological Survey, for his assistance in the compilation of the foregoing Summary of Yorkshire Geological Literature.

LIST OF MEMBERS.

Life members who have compounded for their annual subscriptions are indicated by an asterisk (*)

*ABBOTT, R. T. G., Auburn Hill, Malton.
ADAMSON, S. A., F.G.S., 52, Well Close Terrace, Leeds.
AKROYD, ED., F.S.A., &c., Halifax.
*ALDAM, W., J.P., Frickley Hall, Doncaster.
ALEXANDER, WM., M.D., J.P., Halifax.
ANDERTON, C. P., Cleckheaton.
ATKINSON, J. T., F.G.S., The Quay, Selby.

BAILEY, GEO., 22, Burton Terrace, York.
BAINES, Sir EDWARD, J.P.. St. Ann's, Burley, Leeds.
BALME, E. B. W., J.P., Cote Hall, Mirfield.
BARBER, W. C., F.R.G.S., The Orphanage, Halifax.
BARTHOLOMEW, CHAS., Castle Hill House, Ealing, Middlesex.
BARTHOLOMEW, C. W., Blakesly Hall, near Towcaster.
BAYLEY, REV. T., Weaverthorpe.
BEAUMONT, HY. Elland.
BEDFORD, JAMES, Woodhouse Cliff, Leeds.
BEDFORD, J. E., Burley View, Leeds.
BERRY, WM., King's Cross Street, Halifax.
BINGLEY, GODFREY, Ash Lea, Cardigan Road, Headingley.
BINNIE, A. R., F.G.S., M. Inst.C.E., Town Hall, Bradford.
BOOTH, JAMES, F.G.S., The Grange, Ovenden, near Halifax.
BOOTHROYD, W., Brighouse.
*BOWMAN, F. H., D.Sc.. F.R.A.S., F.C.S., F.G.S., Halifax.
BRADLEY, GEORGE, Aketon Hall, Featherstone.
BRIERLEY, H. G., Huddersfield,
*BRIGG, JOHN, J.P., F.G.S., Broomfield, Keighley.
*BRIGGS, ARTHUR, J.P., Cragg Royd, Rawden, Leeds.
BROADHEAD, JOHN, St. John's Colliery, Normanton.
BROOKE, ED.. jun., F.G.S., Fieldhouse Clay Works, Huddersfield.
BROOKE, Lieut.-Col. THOS., J.P., Armitage Bridge, Huddersfield.

BUCKLEY, GEORGE, jun., Waterhouse Street, Halifax.

BUTLER, J. DYSON, Estate Buildings, Huddersfield.

CAMERON, A. GRANT, of H.M. Geological Survey, 28, Jermyn Street, London, W.

CARR, WM., Halifax.

CARTER, JAS., Burton House, Bedale.

CARTER, R., C.E., F.G.S., Springbank, Harrogate.

*CASH, W., F.G.S., Elmfield Terrace, Halifax.

CHADWICK, WM., Arksey, Doncaster.

*CHARLESWORTH, J. B., J.P., Wakefield.

CHEETHAM, W., Horsforth, near Leeds.

*CLARK, J. E., B.A., B.Sc., F.G.S., 20, Bootham, York.

COLE, REV. E. MAULE, M.A., Wetwang Vicarage, York.

COLE, GEO. B., Wakefield Road, Bradford.

CROSS, BENJ. C., C.E.

CROSSLEY, Lieut.-Col., LOUIS J., J.P., F.M.S., Moorside, Halifax.

CROSSLEY, NEWMAN, Barnsley.

CROWTHER, F., Northowram, near Halifax.

*DAKYNS, J. R., M.A., of H.M. Geological Survey, 28, Jermyn Street, London, W.

DALTON, THOS., Albion Street, Leeds.

DARTMOUTH, Earl of, Patshull House, Wolverhampton.

DAVEY, HY., Rupert Lodge, Leeds.

DAVIDSON, J., F.C.S., Holywell Green, near Halifax

*DAVIS, JAMES W., F.S.A., F.G.S., F.L.S., Chevinedge, Halifax.

DAVIS, R. HAYTON, Harrogate.

*DENHAM, CHARLES, London.

DEWHURST, J. B., Aireville, Skipton.

DOBSON, M. G., Stannary Hall, Halifax.

DODSWORTH, SIR CHARLES, BART., Thornton Watlass, Bedale.

DOLAN, T. M., M.D., F.R.C.S.Ed., Halifax.

DRURY, ED., Halifax.

DUNHILL, C. H., M.D., Gray's Court, York.

DUNNING, JOHN, F.G.S., Assoc. Inst. C.E., Middlesborough.

DYSON, W. COLBECK, F.S.A., Wilton Park, Batley.

EDDY, J. RAY, F.G.S., Carleton Grange, Skipton.

EDWARDS, Lieut-Col., Sir HENRY, Bart., C.B., D.L., J.P., Pye Nest, Halifax.

EFFINGHAM, Earl of, The Grange, Rotherham.

EMBLETON, T. W., C.E., The Cedars, Methley.

EMMOTT, W., The Square, Halifax.

FARRAR, JAMES, Old Foundry, Barnsley.

FILLITER, E., F.G.S., M. Inst.C.E., East Parade, Leeds.

FITZWILLIAM, Earl, K.G., Wentworth Woodhouse, nr. Rotherham.

FLEMING, FRANCIS, Halifax.

FOX, M., jun., Mirfield.

FRAZER, H. J., Fair Lea, Wood Lane, Headingley, near Leeds.

GALWAY, The Viscount, Selby Hall, Bawtry.

GARNETT, WILLIAM, Fairlawn, Ripon.

GASCOIGNE, Col. T., Parlington Park, Garforth, near Leeds.

GASCOIGNE, ROWLAND, F.G.S., Denaby Collieries, Mexbro', near Sheffield.

GAUKROGER, W., Fernside, Halifax.

GLEADHOW, F., Brunswick House, Beverley Road, Hull.

GOUGH, THOS., B.Sc., F.C.S., Elmfield College, York.

*GRAY, THOS. H., Brookleigh, Calverley, Leeds.

GREAVES, J. O., Wakefield.

*GREEN, Prof. A. H., M.A., F.G.S., 14, Ashwood Villas, Headingley.

GREGSON, W., Baldersby, Thirsk.

HAIGH, JOHN, Eightlands, Dewsbury.

HAILSTONE, E., F.S.A., Walton Hall, Wakefield.

HALIFAX, Viscount, Hickleton Hall, Doncaster.

HALLILAY, J., Burley Road, Leeds.

HANSTOCK, JOHN, Denby Grange, near Wakefield.

HARDCASTLE, JOHN, jun., South Milford.

HAWKING, S., Apperley, near Leeds.

HEATON, J. A., Brighouse.

HELLIWELL, T. W., Brighouse.

HEPWORTH, S. C., West Park Street, Dewsbury.

HESLINGTON, T. C., North Road, Ripon.
HEWITSON, H. B., 11, Hanover Place, Leeds.
HIRST, JOHN, Tadcastle, Dobcross, Saddleworth.
HOLGATE, BENJ., F.G.S., 3, Atkinson Street, Hunslet.
HOLROYD, A., Saville Park, Halifax.
HOLT, H. P., C.E., F.G.S., Fairlea, Didsbury, Manchester.
HORNE, WM., Leyburn.
HOUGHTON, Lord, M.A., D.C.L., F.R.S., Fryston Hall, nr. Pontefract
HOWGATE, WM., 139, Woodhouse Lane, Leeds.
*HUDLESTON, W. H., Culverden Lodge, Oaklands Park, Weybridge.
HUNT, H. J., Surgeon, Harrogate.

KELL, ARTHUR A., Barnsley.
KELL, GEO., Barnsley.
KIRBY, JOEL, Mexborough.
KNOWLES, G., Leeds Road, Bradford.

*LAMPLUGH, G. W., F.G.S., 2, Claremont Terrace, Bridlington Quay.
LANCASTER, ED., Barnsley.
LAURENCE, JNO., Barnsley.
LAXTON, F., Rastrick, Brighouse.
LEACH, JOHN, Lindon Road, Halifax.
LEATHER, J. T., Leventhorpe Hall, near Leeds.
LEE, P. F., West Park Villas, Dewsbury.
LEE, J. BANKS, Ripon.
LEEDS, DUKE of, Hornby Castle, Bedale.
LISTER, THOMAS, Victoria Crescent, Barnsley.
LOWTHER, Sir CHARLES, Bart., Swillington Park, near Leeds.
LUPTON, ARNOLD, F.G.S., M. Inst. C.E., 4, Albion Place, Leeds.
LUKIS, Rev. W.C., M.A., &c., The Rectory, Wath, near Ripon.
LUND, PERCY, Ilkley.

MARRIOTT, C. H., J.P., Manor Lawn, Dewsbury.
MARSDEN, THOS. Paper Mills, Barnsley.
MARSHALL, JOHN, F.G.S., Sowerby Bridge, near Halifax.
MARSHALL, STEPHEN A., B.A., Weetwood, near Leeds.

MASON, C. L.. Leeds and County Bank, Leeds.

MAUDE, E., Middleton Hall, Leeds.

MCLANDSBOROUGH, J., F.G.S., F.R.A.S., &c., Manningham, Bradford.

MIDDLETON. CHARLES, Lord Street, Halifax.

MILNE, S. MILNE, Calverley House, near Leeds.

MITCHELL, JOHN, Swaith Hall, near Barnsley.

MITCHELL, JOSH., F.G.S., Worsbro' Dale, Barnsley.

MITCHELL, T. CARTER, Topcliff, Thirsk.

MOISER, H. R., F.G.S., 2, South View, Heworth, York.

MORLEY, GEORGE, Garforth, near Leeds.

*MORRISON, WALTER, J.P., Malham Tarn, near Leeds.

MORTIMER, J. R., F.G.S., Driffield.

MÜLLER, HARRY, Sidcup Hill, Kent.

MYERS, W. BESWICK, Park House, 76, Addison Road, Kensington Road, London, W.

NELSON, HENRY, St. John's Cottage, St. John's Road, Leeds.

NEWHOUSE, WM. HY., Brighouse.

NORTON, WALTER, J.P.. Denby Dale, near Huddersfield.

ORMEROD, HANSON, Boothroyd, Brighouse.

ORMEROD, THOMAS, Brighouse.

PARKE, G. H., F.G.S., F.L.S., Infield Lodge, Furness Abbey.

PAUL, GEO., F.G.S., Moortown, Leeds.

PARSONS, H. FRANKLIN, M.D., F.G.S., 13, Whitworth Road, South Norwood, London, S.E.

PATCHETT, GEORGE, jun., Halifax.

PEACH, ROBERT, Harrogate.

POCKLINGTON, HENRY, F.R.M.S., Park Row, Leeds.

PRATT, THOMAS, M.R.C.V.S., Ripon.

PRESTON, ALFRED ELEY, C.E., F.G S., The Exchange, Bradford.

*RAMSDEN, Sir J. W., Bart., M.P., Byram Hall, near Pontefract.

REUSS, F. W., Dewsbury.

REYNOLDS, RICHARD, F.C.S., Cliff Lodge, Leeds.

*RHODES, JOHN, Snydale Hall, Pontefract.

RIGGE, S. T., F.S.A., Balmoral place, Halifax.

RIPON, The Marquis of, K.G., F.R.S., &c., Studley Royal, Ripon.

ROLLITT, A. K., L.L.D., D.C.L., F.R.A.S., F.G.S., &c., Cogan House, Hull.

*ROWLEY, WALTER, F.G.S., Albion Street, Leeds.

*RYDER, CHARLES, Westfield, Chapeltown, near Leeds.

SADLER, M. T., M.D., Barnsley.

SCARBOROUGH, Geo., Holly Bank, Halifax.

Scarborough Philosophical Society, J. H. PHILLIPS, (Scarborough).

SCARGILL, ALFRED, 11, East Parade, Sheffield.

SCRATCHERD, T. C., Halifax.

SEAL, STEPHEN, F.G.S., Darfield Quarries, Barnsley.

SHARP, C. FORBES, Driffield.

SHAW, JOHN, Darrington Hall, Pontefract.

SHAW, THOMAS, M.P., D.L., J.P., Allangate, Halifax.

SLADEN, W.P., F.G.S., F.L.S., Orsett House, Ewell, Surrey.

SLINGSBY, W. C., Carleton, near Skipton.

SMITH, F., Huddersfield Road, Halifax.

SMITH, WM., F.S.A.S., Osborne House, Morley, near Leeds.

SMITHIES, J. W., Elland.

SORBY, H. C., D.C.L., F.R.S., F.G.S., Broomhill, Sheffield.

STANHOPE, W. T. W. S., J.P., Cannon Hall, Barnsley.

*STANFELD, A. W., Weetwood Grove, near Leeds.

STEEL, R. ELLIOTT, M.A., Spring Cliff House, Heaton Road, Bradford.

STEPHENSON, JOHN, Ormesby Packend, Middlesborough.

STOTT, W., Greetland, near Halifax.

STRANGWAYS, C. FOX, F.G.S., of H.M. Geological Survey, 5, Belgrave Crescent, Scarborough.

*STRICKLAND, Sir CHARLES W., Bart., Hildenley, Malton.

STUBBINS, JNO., F.G.S., Inglebank, Headingley, Leeds.

SWALLOW, D., Gas Works, Bradford.

SYKES, PEACE, 33, Estate Buildings, Huddersfield.

TATE, THOMAS, F.G.S., 4, Kingston Road, Leeds.

TENNANT, J. R.. Kildwick Hall, near Skipton.

TETLEY, Mrs., Foxhills, Weetwood, Leeds.

TETLEY, C. F., Spring Road, Headingley, Leeds.
*TEW, THOMAS W., J.P., Carleton Villa, near Pontefract.
THOMPSON, R., Park Street, The Mount, York.
*TIDDEMAN, R. H., M.A., F.G.S., of H.M. Geological Survey 28, Jermyn Street, London.
TOWNEND, WALTER, Lightcliffe, near Halifax.
TURNER, R. BICKERTON, J.P., East Parade, Leeds.

VEITCH, W. Y., M.D., 37, Grange Road, Middlesborough.
VILLIERS, J., Eastgate, Beverley.
VINE, GEORGE R., 112, Hill Top, Attercliffe, Sheffield.

WALKER, CHARLES, Little Houghton, Darfield.
WALMISLEY, A. T., C.E., F.S.I., 5, Westminster Chambers, Victoria Street, London, S.W.
WARD, CHRISTOPHER, F.L.S., F.Z.S., Halifax.
WARD, GEORGE, F.C.S., Leeds.
*WARD, J. WHITELEY, J.P., F.R.M.S., South Royd, Halifax.
WARD, JOHN, F.G.S., 23, Stafford Street, Longton, Staffordshire.
WARD, W. SYKES, F.C.S., Denison Hall, Hanover Square, Leeds.
WARRINGTON, JOHN, Rawden, near Leeds.
WENTWORTH, F. T. W. VERNON, Wentworth Castle, Barnsley.
WHARNCLIFFE, Earl of, Wortley Hall, Sheffield.
WHEATLEY, CHARLES, Sand House, Mirfield.
*WHITELEY, FREDK., Clare Road, Halifax.
WILSON, E. J., M.A., 6, Whitefriars' Gate, Hull.
WOOD, W. H., Borough Analyst, Halifax.
WOODALL, J. W., J.P., F.G.S., Old Bank, Scarborough.
WOODHEAD, JOSEPH, J.P., Woodthorpe, Huddersfield.

⁂ It is requested that Members changing their residence, will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1884.

Computed from daily observations made at the Exchange, Bradford,

By John McLandsborough, F.E.A.S., F.R.Met.Soc., F.G.S., and Alfred Eley Preston, Assoc. M. Inst. C.E., F.R.Met.Soc., F.G.S.

Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

Months	Pressure of Atmosphere in Month: Highest Reading of Barometer	Date	Mean of Highest of 16 Years	Lowest Reading of Barometer	Date	Mean of Lowest of 16 Years	Range	Corrected for Capillarity and Temperature: Mean	Mean of 16 Years	Temperature of Air in Shade during Month: Highest	Date	Mean of Highest daily of 16 Years	Lowest	Date	Mean of Lowest daily of 16 Years	Range
	Ins	On	In	Ins	On	Ins	Ins	Ins	Ins	Deg	On	Deg	Deg	On	Deg	Deg
January	[illegible]	10th	[illegible]	[illegible]	27th	28·716	[illegible]	[illegible]	[illegible]	54·6	23rd	[illegible]	[illegible]	28th	25·7	21·6
February	[illegible]	4th	[illegible]	[illegible]	10th	[illegible]	[illegible]	29·144	[illegible]	52·8	14th	[illegible]	[illegible]	29th	27·1	25·7
March	[illegible]	24th	[illegible]	[illegible]	10th	[illegible]	[illegible]	[illegible]	[illegible]	66·0	17th	57·2	[illegible]	1st	26·4	[illegible]
April	[illegible]	11th	[illegible]	[illegible]	5th	[illegible]	[illegible]	[illegible]	29·479	61·0	4th	[illegible]	30·4	18th	31·6	30·6
May	[illegible]	[illegible]	[illegible]	[illegible]	4th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12th	69·8	30·0	4th	34·8	45·9
June	[illegible]	14th	[illegible]	[illegible]	2nd	[illegible]	[illegible]	29·651	29·640	[illegible]	29th	[illegible]	[illegible]	1st	41·8	42·7
July	[illegible]	5th	[illegible]	[illegible]	10th	[illegible]	0·621	[illegible]	[illegible]	82	5th	[illegible]	[illegible]	20th	47·0	36·8
August	[illegible]	5th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	84·4	12th	[illegible]	[illegible]	6th	46·1	38·0
September	[illegible]	12th	[illegible]	[illegible]	7th	[illegible]	[illegible]	[illegible]	[illegible]	71·4	22nd	[illegible]	42·2	7th	40·6	29·2
October	[illegible]	5th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29·602	[illegible]	[illegible]	17th	[illegible]	[illegible]	11th	32·6	27·2
November	[illegible]	19th	[illegible]	[illegible]	7th	[illegible]	[illegible]	[illegible]	[illegible]	58·8	8th	56·4	26·5	30th	28·3	32·3
December	[illegible]	22nd	[illegible]	29·040	4th	28·684	[illegible]	[illegible]	[illegible]	[illegible]	15th	53·2	28·9	31st	23·3	25·1
Means, or totals	[illegible]		[illegible]	28·971		28·884	[illegible]	[illegible]	29·496	67·6		65·0	[illegible]		33·6	32·6

Months	Mean in Each Month: Of all Highest	Mean of 16 Years	Of all Lowest	Mean of 16 Years	Daily Range: Mean	Mean of 16 Years	Of Dry Bulb: Mean	Mean of 16 Years	Adopted Mean Temperature: Of Air: Mean	Mean of 16 Years	Of Evaporation: Mean	Mean of 16 Years	Dew Point: Mean	Mean of 16 Years	Vapour: Elastic Force: Mean	Mean of 16 Years	In a Cubic Foot of Air: Mean	Mean of 16 Years	Short of Saturation	Mean of 16 Years	Mean Weight of a Cubic Foot of Air	Mean of Sixteen Years
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	In	Ins	Grs	Grs	Grs	Grs	Grs	Grs
January	46·9	[illegible]	[illegible]	34·6	7·8	8·7	43·1	39·5	43·0	39·0	[illegible]	37·3	[illegible]	35·0	236	206	2·7	2·4	0·5	0·4	545	548
February	45·4	44·7	36·9	35·8	8·5	[illegible]	41·2	40·2	41·0	40·0	39·1	38·3	[illegible]	36·0	215	213	2·6	2·5	0·5	0·4	545	547
March	48·7	47·1	[illegible]	[illegible]	11·4	11·4	42·4	40·9	42·2	40·6	[illegible]	38·2	35·8	35·3	210	207	2·5	2·4	0·6	0·5	544	547
April	51·1	53·4	38·5	39·9	12·6	13·5	43·3	45·2	43·3	45·2	40·4	41·9	36·5	38·0	[illegible]	[illegible]	2·5	2·7	0·8	0·8	542	541
May	61·8	58·7	44·5	[illegible]	17·3	16·0	[illegible]	49·6	50·8	49·5	46·2	45·1	41·4	41·0	261	[illegible]	3·0	3·0	1·2	1·1	[illegible]	537
June	64·9	[illegible]	48·9	[illegible]	16·0	15·1	[illegible]	55·8	55·2	55·7	50·6	51·3	46·2	46·9	[illegible]	322	3·6	3·6	1·4	1·3	533	539
July	68·4	[illegible]	54·6	54·0	13·8	14·7	[illegible]	60·4	59·7	60·3	[illegible]	54·6	51·4	50·5	380	[illegible]	4·2	4·1	1·5	1·7	525	526
August	[illegible]	[illegible]	54·9	[illegible]	16·4	14·5	61·3	[illegible]	[illegible]	59·2	55·5	54·5	50·6	50·7	367	371	4·1	4·2	[illegible]	1·5	525	526
September	[illegible]	62·3	[illegible]	[illegible]	12·6	12·6	56·3	54·6	[illegible]	54·0	53·1	51·6	[illegible]	48·3	[illegible]	340	4·1	3·8	1·0	1·0	531	[illegible]
October	53·6	54·2	42·2	43·4	11·4	10·8	48·1	48·6	47·5	48·1	44·8	45·8	41·9	43·0	[illegible]	[illegible]	3·1	3·2	0·7	0·6	540	537
November	[illegible]	47·2	38·0	36·0	10·0	9·2	[illegible]	42·7	42·7	42·2	40·0	40·0	36·7	[illegible]	218	[illegible]	2·5	2·6	0·6	0·5	548	544
December	45·2	42·6	35·5	34·3	7·7	8·3	39·3	39·1	39·3	38·8	37·2	36·8	34·5	34·3	200	200	2·3	2·3	0·5	0·5	545	548
Means, or totals	56·6	54·7	44·5	42·8	12·1	11·9	48·6	48·0	48·5	47·6	45·2	44·7	41·7	41·3	271	268	3·1	3·1	0·9	0·9	538	538

Months	Degree of Humidity (Complete Saturation = 100): Highest	Date	Mean of Highest of 16 Years	Lowest	Date	Mean of Lowest of 16 Years	Mean	Mean of 16 Years	Temperature of Air in Sun's Rays: Highest	Date	Mean of Highest of 16 Years	Mean	Mean of Sixteen Years	Wind: Direction, Relative Proportion of at 9 a.m.: N	NE	E	SE	S	SW	W	NW	Pressure: Mean at 9 a.m.	Mean of all Highest	Highest	Direction	Date	Mean Amount of Cloud	Rain: Number of Days it fell	Amount Collected	Greatest Daily Fall	Date	Mean of Fifteen Years	Mean of Seven Years ending with 1882 on roof	Mean of 7 Yrs. ending with 1882 at Town Hall and Mid. Ry. Station on surface of ground	Greater fall on surface at Town Hall & Mid. Stn. than on roof above surface at Exch'ge: Depth in Inches	Percentage of fall at Exch'ge
	0–100	On	0–100	0–100	On	0–100	0–100	0–100	Deg	On	Deg	Deg	Deg	No	No	No	No	No	No	No	No	lbs per sq ft	lbs per sq ft	lbs per sq ft		On	0–10	No	In	Ins	On	Ins	Ins	Ins	Ins	Per cent
January	98	23rd	96	[illegible]	30th	[illegible]	85	[illegible]	[illegible]	16th	[illegible]	[illegible]	48·2	0	1	1	1	2	6	5	12	1·4	[illegible]	[illegible]	W N W	[illegible]	8·7	18	[illegible]	1·17	23rd	[illegible]	[illegible]	[illegible]	0·265	11·2
February	96	19th	[illegible]	[illegible]	[illegible]	70	84	[illegible]	[illegible]	[illegible]	72·1	52·1	52	2	[illegible]	4	[illegible]	4	7	5	1	1·0	[illegible]	11	S S W	[illegible]	8·4	20	3·13	[illegible]	[illegible]	2·05	[illegible]	[illegible]	[illegible]	11·1
March	96	4th	96	[illegible]	[illegible]	57	79	83	[illegible]	16th	[illegible]	[illegible]	[illegible]	1	4	2	8	4	5	6	1	0·6	[illegible]	[illegible]	S W	21st	7·8	16	1·65	0·71	6th	[illegible]	[illegible]	[illegible]	[illegible]	11·7
April	96	28th	94	45	22nd	55	75	[illegible]	[illegible]	9th	[illegible]	69·7	[illegible]	2	15	3	4	2	2	1	1	[illegible]	1·78	[illegible]	E N E	14th	7·8	21	[illegible]	0·37	28th	[illegible]	2·516	[illegible]	[illegible]	11·2
May	87	4th	[illegible]	30	22nd	46	71	73	[illegible]	12th	[illegible]	79·8	81·9	1	6	3	[illegible]	2	10	5	2	[illegible]	3·35	[illegible]	S W	5th	[illegible]	14	[illegible]	0·42	4th	1·59	[illegible]	[illegible]	[illegible]	[illegible]
June	89	5th	92	[illegible]	[illegible]	51	72	72	[illegible]	29th	112·3	[illegible]	87·8	4	4	2	4	1	5	2	6	[illegible]	[illegible]	[illegible]	W S W	25th	7·7	10	[illegible]	0·43	6th	[illegible]	[illegible]	[illegible]	[illegible]	10·6
July	97	17th	91	49	3rd	[illegible]	74	[illegible]	[illegible]	7th	114·4	[illegible]	92·1	[illegible]	2	1	4	8	9	3	3	0·6	1·65	[illegible]	W S W	[illegible]	[illegible]	25	[illegible]	1·04	[illegible]	[illegible]	[illegible]	[illegible]	0·240	10·7
August	89	7th	92	42	11th	[illegible]	68	[illegible]	[illegible]	9th	112·3	91·6	[illegible]	1	6	3	3	5	5	4	4	0·5	[illegible]	[illegible]	W	[illegible]	6·5	8	[illegible]	[illegible]	28th	[illegible]	[illegible]	[illegible]	[illegible]	10·7
September	94	16th	95	47	2nd	57	80	79	[illegible]	14th	101·5	79·9	80·5	6	2	2	2	4	8	5	2	1·0	[illegible]	[illegible]	W S W	[illegible]	6·9	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11·2
October	96	9th	97	53	1st	62	82	[illegible]	81·8	6th	[illegible]	63·7	66·8	2	2	1	4	2	5	5	[illegible]	0·8	[illegible]	[illegible]	W S W	[illegible]	7·1	17	1·50	[illegible]	28th	[illegible]	[illegible]	[illegible]	[illegible]	11·0
November	94	11th	96	53	8th	63	86	[illegible]	[illegible]	[illegible]	[illegible]	52·2	54·9	9	1	1	3	5	3	3	6	0·8	[illegible]	[illegible]	S W	5th	7·7	17	1·14	0·33	5th	[illegible]	3·421	[illegible]	[illegible]	11·2
December	96	2nd	98	70	24th	[illegible]	[illegible]	84	[illegible]	15th	57·1	43·1	46·1	2	3	0	3	2	7	6	6	1·2	4·49	[illegible]	N	5th	8·1	22	4·25	0·53	19th	2·87	3·661	[illegible]	[illegible]	11·3
Means, or totals	94		94	51		[illegible]	78	79	[illegible]		89·9	67·6	[illegible]	30	51	23	44	41	72	50	55	0·8	2·81	[illegible]			7·6	204	[illegible]	[illegible]		[illegible]	35·741	[illegible]	[illegible]	[illegible]

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, and Humidity from 1869 to 1884, and Rainfall from 1870 to 1884, inclusive.

Year	Pressure: Highest: Reading of Barometer during Year	Date	Lowest: Reading of Barometer during Year	Date	Temperature: In Shade: Highest: Reading of Maximum Thermometer during Year	Date	Lowest: Reading of Minimum Thermometer during Year	Date	Last and First Frost of Season: Date of Last Frost	Date of First Frost	In Sun's Rays: Highest: Reading of Solar Thermometer during Year	Date	Humidity (Complete Saturation = 100): Highest: Degree of Humidity during Year	Date	Lowest: Degree of Humidity during Year	Date	Rain: Total for Year	Mean Yearly Rainfall at Town Hall and Mid. Ry. Station on surface of ground	Greater fall on surface at Town Hall & Mid. Rly. Station than on roof above surface at Exchange: Depth in Inches	Percentage of fall at Exch'ge	Greatest Daily Fall during Year	Date	Snow: Last and First Snow of Season: Date of Last Snow	Date of First Snow
	Ins		Ins		Deg		Deg				Deg		0–100		0–100		Ins	Ins	Ins	Per cent	Ins			
1869	30·290	Dec 6	[illegible]	Feb 1	85·2	Aug 30	19·8	Dec 28	Mar 27	Oct 20	127·7	Aug 30	99	Feb 8	42	Sep 24							April 3	Oct 19
1870	30·284	Jan 19	28·308	Jan 8	[illegible]	July 25	16·6	Dec 23	Mar 30	Nov 9	127·5	July 25	98	Jan 29	40	July 14	24·120				0·620	June 18	Mar 21	Nov 15
1871	30·152	Mar 28	[illegible]	Jan 16	84·0	Aug 12	6·7	Jan 1	April 11	Nov 13	128·7	July 17	98	July 7	43	Nov 2	[illegible]				0·985	June 16	Mar 15	Nov 16
1872	30·166	April 6	28·070	Jan 24	86·4	July 23	24·8	Mar 27	Mar 27	Nov 19	124·8	Aug 19	100	Mar 22	45	Sep 23	[illegible]				2·490	June 19	May 11	Nov 15
1873	[illegible]	Feb 18	[illegible]	Jan 20	[illegible]	July 23	19·2	Feb 24	Mar 14	Nov 5	124·5	July 23	100	Dec 11	41	Mar 26	21·410				1·200	Aug 4	April 25	Jan 3, '74
1874	30·476	Mar 6	28·276	Dec 11	80·9	July 20	15·0	Dec 31	Mar 12	Nov 11	125·8	July 20	100	Feb 6	42	May 18	[illegible]				0·740	Dec 7	May 9	Nov 26
1875	[illegible]	July 7	28·484	Nov 10	80·0	Aug 17	13·0	Jan 1	Mar 22	Nov 26	122·0	July 5	100	Jan 23	43	July 6	[illegible]				1·700	Nov 15	Mar 12	Nov 9
1876	[illegible]	Jan 15	28·070	Dec 4	87·6	July 17	23·0	Jan 9	April 15	Nov 9	125·6	July 16	99	Oct 4	46	May 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Oct 9	April 12	Nov 8
1877	[illegible]	Oct 6	28·300	Nov 29	80·0	June 19	20·0	Mar 1	May 4	Oct 18	116·1	June 19	100	Oct 29	35	May 23	[illegible]	45·499	4·849	11·19	1·420	July 16	May 19	Oct 15
1878	[illegible]	Mar 16	[illegible]	April 1	89·6	July 19	13·9	Dec 26	April 6	Nov 9	116·2	July 22	99	Jan 13	63	Aug 9	[illegible]	39·016	3·576	11·01	[illegible]	Aug 14	April 1	Nov 8
1879	30·352	Dec 13	28·500	Feb 10	74·4	July 30	13·2	Dec 7	May 16	Nov 14	101·2	Aug 13	100	Oct 7	51	Dec 12	26·017	[illegible]	[illegible]	10·82	1·020	June 8	May 7	Nov 20
1880	30·332	Jan 7	28·154	Nov 16	81·3	Sep 5	20·8	Jan 20	Feb 23	Oct 20	112·0	Aug 13	99	Dec 15	50	May 30	[illegible]	39·616	3·426	11·10	1·710	Oct 27	Mar 2	Oct 27
1881	[illegible]	May 10	28·250	Oct 14	83·3	July 6	12·0	Jan 26	April 21	Oct 17	116·5	June 1	98	Oct 14	38	May 31	35·434	39·862	4·458	11·26	1·435	Oct 13	April 20	Oct 29
1882	30·544	Jan 18	28·452	Mar 1	77·4	Aug 12	18·6	Dec 11	April 16	Nov 12	108·0	Aug 9	99	Nov 5	36	May 18	39·683	43·103	3·420	10·86	1·608	Dec 6	Mar 21	Nov 19
1883	30·560	April 9	28·452	Sep 2	76·2	July 3	19·8	Mar 10	Mar 29	Nov 12	107·6	May 17	99	Dec 26	30	April 9	[illegible]				1·358	Sep 26	Mar 24	Nov 10
1884	30·354	Oct 5	28·376	Jan 27	84·4	Aug 12	26·5	Nov 30	April 24	Nov 24	107·8	Aug 9	98	Jan 23	30	May 22	27·657				1·170	Jan 23	Feb 28	Nov 23
Means	30·340		28·322		82·8		17·7				118·4		99		42		31·689	39·601	3·860	11·08	1·378			

EXPLANATION

The observations are made at nine a.m. daily, with the exception of maximum and minimum thermometer readings, [illegible] three p.m.

The highest and lowest barometer readings for each month, also the monthly range, are given as recorded, while the mean pressure is deduced from the daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude, or reduce to sea level, the air temperature being 45 degrees and barometer reading 30 inches at sea level, add ·401 inch to the heights given.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from the daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction and pressure of wind are recorded as indicated by an Anemometer fixed 10½ feet above the ridge of roof of Exchange. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and [illegible] feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open places, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were discontinued, the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·860 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the fifteen years ending with 1884 is 31·689 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 35·2[illegible] inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange and on buildings generally than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof, the place it has since occupied. To avoid risk of inaccurate results the rainfall of 1869 is omitted from these returns.

All the instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

Procee
N. S.
FEB 1
JAN 1

AMNH LIBRARY
100218628